CONNECTICUT RIVER FLOOD CONTROL PROJECT

HARTFORD, CONN.

CONNECTICUT RIVER, CONNECTICUT

ANALYSIS OF DESIGN FOR NORTH MEADOWS PUMPING STATION

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CORPS OF ENGINEERS, U. S. ARMY

U.S. ENGINEER OFFICE PROVIDENCE, R.I.

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UNITED STATES ENGINEER OFFICE PROVIDENCE, RHODE ISLAND

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I. INTRODUCTION

I. INTRODUCTION

A. Authorization and past reports. - The North Meadows pumping station is a part of the local protection works for the City of Hartford. The original project report was submitted December 8, 1936, and is included in the Comprehensive system for flood control recommended by the District Engineer in "Report of Survey and Comprehensive Plan for Flood Control in the Connecticut River Valley," dated March 20, 1937, approved by the Chief of Engineers November 29, 1937, and published as House Document No. 455, 75th Congress, 2d Session. The project is authorized under the Flood Control Act approved June 28, 1938.

B. Necessity for the station. - The building of the dike from the Memorial Bridge at Morgan Street to Windsor Avenue would result in preventing natural drainage into the Connecticut River of an area of about 1,340 acres included between the tracks of the New York, New Haven, and Hartford Railroad and the river. This is the drainage area remaining after the diversion of Meadow Brook north of the dike section. To prevent the accumulation of water behind the dike and the resultant flooding of the North Meadows section of Hartford, a pumping station is to be constructed which will discharge the accumulated water into the Connecticut River at river stages which are too high for gravity flow. The water from natural drainage will be accumulated in a small storage pond which will smooth out peak run-off rates and reduce the pumping capacity required. During periods of normal river stage this pond will empty into the Connecticut River through a gravity flow conduit extending from the pond through the dike, where the conduit will terminate in an open ripraplined channel to the river. Pumping will be necessary when the river stage exceeds Elevation 6.0. The pond will have a capacity of 60 acre-feet between Elevations 4.0 and 8.0 m.s.l. and will serve to store all peak discharges in excess of the pumping or gravity-flow capacity of the conduit.

C. Consultation with the City of Hartford. - Preliminary to and during the actual design of the station, consultations were held with officials representing the City of Hartford and the Flood Commission of Hartford. The proposed station layout was studied by them, and in conferences the relative merits of the layouts proposed and the equipment to be used were discussed in detail. Mr. Charles Bennett, Consulting Engineer of Hartford, is Executive Secretary of the Flood Commission and Messrs. Charles H. Paul of Dayton, Ohio, and William F. Uhl of Boston are consultants of the Commission. The pumping station design, as finally developed, meets with the approval in its essentials of the City of Hartford and its Flood Commission.

D. Short description of the station. - The building which will house the pumps and other equipment will be two stories high. The substructure will be entirely of reinforced concrete except for walkways and steady beams in the pump room, and will house three 36-inch mix flow pumps and one 16-inch mix flow pump. The superstructure, which includes everything above the machinery room floor will be of brick, structural steel, and reinforced concrete. Glass brick panels in the brick walls will take the place of windows. The concrete roof slab will be covered with a fill of sawdust concrete on which a 4-ply asphalt and gravel roofing will be placed. The machinery room floor will contain the gasoline engines for the gasoline-driven pumps, an electric motor for the 16-inch pump, two gasoline-electric generator sets, panel board, etc. Space has been provided for the installation of a future 36-inch gasoline-driven pump. Suction and gravity flow conduits are provided, the gravity flow conduit acting as a pressure conduit when the pumps are in operation.

II. SELECTION OF THE SITE

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The pumping station is located 150 feet northeast of the center line of Meadow Brook and 142 feet northwest of the center line of the dike. This location was chosen for the following principal reasons: first, because it is the lowest point in the meadow; second, because there is ample room for the excavation of the storage pond; third, because foundation conditions are satisfactory on which to construct the pumping station. Borings and laboratory tests show that the soil found here will offer ample resistance to all the superimposed loads without the use of piling.

III. SOIL INVESTIGATION

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Subsurface explorations were accomplished by core borings on the approximate axis of the building and gravity flow conduit. The locations of these borings are shown on Plate No. 4. These investigations were made to determine the nature of the subsoil and its ability to withstand the proposed loads.

The core boring under the building shows that the pumping station will be founded on a bed of uniform fine sand to coarse silt (Class 6) underlain by a thin bed of material grading from gravel to fine sand (Class 5). The total thickness of the two beds after excavation will be about five feet. A thick bed of clay underlies the whole.

The core boring near the intersection of the axis of the dike and the axis of the gravity flow conduit shows that the conduit at this point will be founded on a layer of medium to fine sand (Class 4 to Class 2), which will be about seventeen feet thick after excavation, underlain by a thick bed of uniform clay.

Because of the large amount of overburden to be removed at the pumping station site, approximately equal in weight to the proposed structure, no appreciable settlement of the building is expected. For the conduit under the dike a maximum settlement of 3 inches under the highest part of the dike fill, due to compressibility of the soil, may take place. No settlement of the conduit is expected at the foot of the dike slopes. To take care of possible settlement under the dike the conduit will be built with a 3-inch camber, which it is expected will be taken out as the subsoil is consolidated by the superimposed dike fill.

square foot at the edge of the dike and 4,000 lbs. per square foot at the center of the dike. The latter value is well within the safe bearing capacity of the soil. No settlement of the conduit is expected at the foot of the dike slopes. To take care of possible settlement under the dike the conduit will be built with a 3-inch camber, which it is expected will be taken out as the sub-soil is consolidated by the superimposed dike fill. The conduit is divided into sections each about forty feet long. Expansion joints with copper water stops are provided between these sections. These should provide sufficient flexibility for any settlement that takes place so that no cracks should occur in the reinforced concrete.

The possibility of seepage under the conduit foundation will be greatly reduced by the steel sheet pile cut-off near the outlet end and by seep rings cast integrally with the conduit.

IV. HYDROLOGY

IV. HYDROLOGY

A. Drainage area. - The drainage area which contributes to the North Meadows pumping station comprises 1,340 acres of residential, industrial and agricultural land as shown on Plate 1. The residential area is on the upland and is generally provided with storm sewers. The industrial development is limited at present to a narrow fringe between the residential upland and the valley floor. The agricultural area includes roughly 700 acres and is located on the relatively flat valley floor adjacent to the Connecticut River.

B. Run-off. - The rates of run-off to be expected from the contributing drainage area are not large. The residential area, covering about one-third of the total watershed, is provided with storm sewers, but the terrain is not particularly steep. The valley floor is relatively flat, sloping gently away from the river and the pumping plant. In spite of these mitigating circumstances, a run-off coefficient of 60 per cent was assumed for the months of June, July, August and September, and 100 per cent for the rest of the year.

C. Seepage. - The seepage flow beneath the dike which may be expected will be small, because of the precautions taken in the dike construction, which include an earth blanket of impervious material and a sheet steel piling cut-off. It will be greatest at high river stages, when the surface run-off will not be heavy, as will be discussed later.

D. Connecticut River stages. - The head against which storm run-off must be pumped is a function chiefly of the stage of the Connecticut River. Plate 12 is a stage-duration curve of the Connecticut River at the pumping station outlet.

E. Storage pond. - Water will be brought to the pumping station in the channel of Meadow Brook. It is feasible to enlarge a small existing pond near the mouth of this brook to create a storage pond from which the pumps will draw water. Sanitary sewage is handled by a separate system, and so there will be no objection to this open pond from a public health point of view. The pond will be of great value in absorbing minor variations in the flow coming to the pumping station, and will also serve, by temporarily storing peak discharges, to reduce the required pumping capacity. Consideration of the local topography led to the selection of elevation 8.0 m.s.l. as the maximum pond level. Above this stage, an excessive area of the meadow land would be required for the pond. Low stages of the Connecticut River governed the selection of elevation 4.0 m.s.l. as the minimum pond level; the river is above this stage about 45 per cent of the time.

F. Study of past storms and simultaneous river stages. - A history of storms having over 1.5 inches of rainfall in 24 hours, occurring during the past 33 years, together with the simultaneous Connecticut River stages, was studied to learn something about the typical conditions which might be expected for storms in the future. Since no run-off records are available for areas similar to the drainage area in question, hourly rainfall data at Hartford were utilized, the run-off coefficients mentioned in Paragraph B were applied, and the run-off was assumed to appear immediately at the pumping plant. This latter assumption serves to counteract the fact that the true maximum rainfall occurring within one hour may appear partially in each of two consecutive clock hours, and hence be not evident in the hourly record. For each storm were tabulated the river stage and the maximum flow which it would be required to discharge through the dike, for the three conditions: no storage pond, 40 acre-feet of storage, and 60 acre-feet of storage. These data were then plotted, separately for each assumed storage capacity: zero, 40 acre-feet, and 60 acre-feet. The required discharge capacity, based on the past records, decreased rapidly with increasing storage, and it was immediately evident that, with 60 acre-feet of storage, the saving in pumping plant cost would be greater than the cost of providing the larger pond. This capacity will be obtained in a 15-acre pond, between elevations 4.0 and 8.0 m.s.l.

The plot based on 60 acre-feet of storage, Plate 13, shows that the required discharge capacity decreases with increasing river stages; the most intense storms have occurred with the river below elevation 6. Points representing run-off during the three major floods of record are labeled with the date of occurrence.

V. REQUIRED DISCHARGE CAPACITY

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A. Design criterion for capacity. - The criterion for pumping capacity provide for: (a) Pumping against a maximum head equal to the maximum predicted flood height in the Connecticut River; (b) Keeping below a minimum damage level inside the protected area the runoff from any intense, concentrated storm (not the maximum possible) experienced in the period of record. The assumptions made in the studies of past storms are conservative, and yet the occurrence of a maximum storm over the contributing drainage area would create conditions much more severe than any which have occurred in the past, especially if it occurred during an extremely high Connecticut River stage.

B. Pump capacity. - The pumps will be required to discharge storm flow whenever the river stage is above elevation 6. The required discharge capacity of the pump, based on the design criterion used, was set as follows:

River elevation	6	16	26	36
Discharge capacity, c.f.s.	300	200	120	50

The total capacity of the pumps selected is shown on the plot. It may be seen that the required pumping capacity for a few storms of record is greater than the pumps provide. A further study was made of these storms, viz., those of April 14, 1909, April 12, 1934, May 15, 1937, and September 20 - 21, 1938, to ascertain the extent of the area which would have been flooded under the assumed conditions of run-off and with the pump capacity and storage pond as selected. Included in the study is a storm which has been given by the Weather Bureau as a maximum possible storm in this area. Run-off from this storm was assumed to be 60%. The following table summarizes the study:

Storm	River Stage	Storm Rainfall	% of Run-off Assumed	Extent of Flooding			
				Assuming Actual River Stage		Assuming River at Maximum Flood Stage	
				Pond rises to elev.	Acres flooded, excluding pond area	Pond rises to elev.	Acres flooded, excluding pond area
April 14, 1909	14	4.02" in 31 hrs.	100%	9.8	21	12.2	87
April 12, 1934	13.5	2.86" in 18 hrs.	100%	8.8	7	11.6	65
May 15, 1937	11	2.05" in 13 hrs.	100%	8.8	7	11.1	50
Sept. 20, 1938	13	(4.92" in 15 hrs.) (6.21" in 22 hrs.)	60%	9.3	14	11.7	82
Weather Bureau Maximum	--	(9.8" in 8 hrs.) (11.6" in 16 hrs.)	60%	13.7*	143*	14.8	297

* River assumed at elev. 10.

Bearing in mind the conservative assumptions upon which the required discharge capacity for each storm was computed, and the small damage which would occur if some land adjacent to the pumping pond were to be flooded at rare intervals, it was not considered justifiable to provide pumping capacity at this time to cover these cases. The pumping station will be provided with space for an additional unit which may be installed when greater development of the area shows the need. The original pumping installation is made up of four pumps: three 36-inch pumps with a maximum discharge of 100 c.f.s. each, and a 16-inch pump with 14 c.f.s. capacity. The small pump is intended to handle normal flows from the area, and the large pumps will be used only during periods of excessive storm run-off.

C. Economic consideration. As pointed out in paragraph B, an estimated area of 297 acres will be flooded under maximum conditions as estimated by the U. S. Weather Bureau for that region, with the proposed pump capacity. At the present time the damage due to such flooding would be of little consequence. The areas which would be flooded because of insufficient capacity are low-lying areas which are not intensely utilized at the present time because they are subject to frequent flooding. The completion of the local protective works will undoubtedly increase the utilization of these lands. It is considered essential to provide them with an adequate degree of protection. A low-cost housing development is planned for a considerable portion of the North Meadows area. Some of the remaining land area will be set aside for industrial development. Any appreciable or protracted rise of the ground-water level, which would be caused by excessive flooding of the storage pond, would seriously damage these developments.

Damages begin at elevation 16 for present agricultural development, which is just above the limit of the capacity of the pump under the assumed maximum condition. Future development of the area will lower the elevation at which damage begins.

D. Open-channel, or gravity-flow capacity. Storm run-off will flow by gravity through the open conduit under the dike when the river is low, and will be pumped through the same conduit when the river is above the maximum pond level.

The plot mentioned in the last paragraph of the previous section indicates that, if the run-off assumptions used are correct, the conduit should have a maximum capacity of over 1,000 second-feet. The channel selected has a maximum capacity of about 500 c.f.s. The justification for this apparently inadequate capacity is the fact that if the Connecticut River is as low as stage 6, it may be assumed quite dependably that there can have been no recent heavy general rains; the ground will not be saturated, and the run-off, even for an excessive storm, will probably not be as great as assumed.

The capacity of the conduit selected is shown on the plot.

c. Operation. - The pond will be kept normally at elevation 6 m.s.l. One of the large pumps and the small pump can draw the water surface from elevation 6 to elevation 4 in one and one-half hours when the inflow is small. Depending upon the local conditions, one or more pumps may be started when rain begins, and if heavy rain occurs or threatens, the pond will be drawn down as rapidly as possible to elevation 4 or below.

During periods when the river is above elevation 6, and the local run-off is small, the flow will be pumped by the small pump. The stage-duration curve shows that pumping will be necessary about one-fourth of the time. During this period the large pumps will be operated for a period of 10 days.

F. Comparison with other pumping stations. - As a result of its studies for the North Meadows Pumping Station, the City of Hartford proposed an initial installation of two 36-inch pumps and two 24-inch pumps, or a total capacity of 170 c.f.s. at a head of 22 ft., and a final installation of four 36-inch pumps and two 24-inch pumps having a total capacity of 310 c.f.s. at a head of 22 ft. The gravity conduit in the Hartford plan had a capacity slightly larger than that selected by this office.

In connection with the existing flood protection works in the southern part of Hartford which comprise the Clark and Colt dikes, built several years ago, there is a pumping station constructed by the City of Hartford.

This South Meadows Station serves a drainage area of 1,100 acres. It has a pumping capacity of 293 c.f.s. at 20 ft. head. As a result of the 1938 flood, this pumping station is now considered inadequate by the City of Hartford and will be enlarged in capacity.

The City of Springfield has four pumping stations designed by Metcalf & Eddy in 1938. Pertinent data concerning these plants and the Hartford plants are given in the following table:

Pumping Station	Drainage Area Acres	Pump Capacity c.f.s.	Pump Capacity c.f.s. per acre	Remarks
Proposed Hartford North Meadows	1340	220 @ 20 ft. 90 @ 33 ft.	0.16 0.07	60 acre-foot storage pond = .54" of run-off.
Hartford South Meadows	1100	293 @ 20 ft.	0.27	Inadequate in 1938
Springfield - Clinton St.	807	141 @ 20 ft.	0.17	
(Phelps Av.) Worthington St.	665	324 @ 20 ft.	0.49	
Union St.	255	141 @ 20 ft.	0.55	
York St.	263	141 @ 20 ft.	0.54	

VI. MECHANICAL DESIGN

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A. Selection of equipment. - Prior to the selection of the pumping station equipment, a study was made to determine the means to be employed to drive the pumps and station auxiliaries. Three possible methods were considered; namely, electric motor, Diesel engine and gasoline engine. No electric power is available at the immediate site. The closest power line is located approximately a mile from the site and is of only sufficient capacity to supply the station auxiliaries. To connect the pumping station with a satisfactory source of current would require a transmission line of about two miles in length, part of which would cross a swale. Past experience has shown that in order to be reasonably certain that the pumping station will be able to function under adverse conditions, at least two and preferably three individual sources of power with independent transmission lines are necessary. Three independent sources are considered the very minimum in this case because of the past failures of the power supply at Hartford which have included generating equipment, substations, and transmission lines. In view of the additional cost involved in constructing transmission lines to several independent sources of power, the proposal to employ electric power was discarded.

The possible use of Diesel engines to drive the pumps was then investigated. The conclusion reached was that the engines would be suitable for the purpose intended, but that their high first cost would not be offset by the low operating cost, due to the small annual period of operation, and that gasoline engines would serve the purpose equally as well.

The employment of gasoline engines was next considered. It was determined that engines of suitable power and speed characteristics could readily be obtained and at reasonable first cost. The operation of the engines was then studied. The failure of one engine, while possible, is unlikely and the failure of two or more engines simultaneously is very remote. In the event that an engine failed, the danger of flooding during the interim while it was being repaired would be alleviated by the excess capacity of the remaining pumps over that which is required of them and the storage capacity of the pond. Considering the above factors, the proposal to use gasoline engines to drive the pumps was adopted.

B. Pumps. -

1. Requirements affecting the choice of pumps. - The principal requirements affecting the choice of pumps were as follows:

a. They should meet the requirements as to head and capacity.

b. They should be able to pass large amounts of debris without clogging.

c. As they are to be driven by gasoline engines, the brake horsepower characteristics should approach a flat curve when plotted under all conditions of head.

In view of the above conditions, the mix flow type of pump was selected. Its characteristics are such that the impeller will pass large solids, it can meet the head and capacity requirements with excess capacity in the higher heads over that which is required (see Plate No. 14), and the brake horsepower is a comparatively flat curve resulting in a uniform load on the gasoline engine.

2. Determination of size of pumps. - The size of the pumps was determined by three factors.

a. The pumps shall be of such size that in the event that one should fail the pond storage and the capacity of the remaining pumps will be sufficient to prevent flooding during the time that repairs are being made.

b. The pumps shall be of such a size that their power requirements will not exceed the range of standard gasoline engines. In addition the pumps and engines should be so matched that the pump will not be underpowered nor will the engine deliver excess power not required.

c. The economic conditions developed by using combinations of various sizes of pumps.

A study of the characteristic curves for various sizes of pumps shows that three 36-inch pumps can be employed to best advantage. They will deliver the required capacity at the lower heads and provide an excess at the higher heads. Their power requirements (approximately 240 horsepower) can be met by standard gasoline engines. Hydraulic studies indicate that the large pumps will operate on an average of 10 days a year.

To relieve the necessity of frequent stop and start operation of such large pumps for minor run-off conditions, a 16-inch mix flow pump has been provided. Studies indicate that this pump will be operated approximately 80 days per year. It will be electric motor powered, the current to be supplied by a gasoline engine generator set. The 16-inch pump is electric motor powered because of the fact that when the pumping station is operating, electric current is required for lights and station auxiliaries and rather than operate two gasoline engines, one for the pump and one for the generating unit, the capacity of the generating unit was increased to take care of the pump motor requirements.

C. Gasoline engines. - The gasoline engines will be of the heavy duty industrial type capable of continuously driving the pumps at their rated speed under any head condition developed, with an engine speed of not more than 1200 r.p.m. The engines will not use over 85 per cent of the developed horsepower (approximately 300 horsepower). They will be mounted on concrete bases and direct connected through a flexible coupling to the right angle gear units.

D. Right angle gear units. - The gear units will be of the self-contained type designed for transmitting the power from the horizontal engine shaft through a set of spiral bevel gears to the vertical pump shaft. The unit will be enclosed in a cast iron housing. Gears will be precision generated of alloy steel, heat-treated and lapped. Shafts will be made of forged heat-treated steel supported on anti-friction bearings of the radial thrust type. The entire unit will have a service factor of not less than 1.25.

E. Engine cooling water system. - The City water supply will be brought to the pumping station in a separate pipe line, which is not considered to be of a dependable nature, consequently an independent cooling water system has been provided for the gasoline engines. It consists of a series of well points interconnected to two centrifugal pumps which pump the water to the gasoline engines and exhaust lines. The pumps will be electric motor driven and of the split-case, single suction, bronzefitted, centrifugal type, capable of delivering 150 g.p.m. at a head of 50 feet. One pump will provide sufficient water for the station's needs, the other will be available in the event of failure of the first. Test holes have been sunk to ascertain the flow, and the water tested to determine its suitability for the purpose intended.

F. Light and power system. - The light and power system is made up of two gasoline generator units, switchboard, conduit and wiring. Two generating units are provided so that in the event one fails the other will furnish the necessary current to the station auxiliaries. The first unit will have a rating of 93.8 kv-a. at 80 per cent power factor, which is sufficient to operate the 16-inch pump and the station auxiliaries. The second unit will have a rating of 31.3 kv-a. at 80 per cent power factor which is ample for the station auxiliaries. The switchboard will provide for the control and distribution of power.

G. Sluice gates. - Two hydraulically-operated sluice gates will be located at each end of the discharge conduit. During the period of gravity flow from the pond to the river, both sets of gates will be open. During the time that the pumps are in operation, the intake gates will be closed, thereby preventing back flow to the pond. The gates at the discharge end of the conduit will be closed only at times of emergency or when the conduit is being inspected and repaired. Power to operate the gates will be obtained from an electric motor driven gear type pump which will furnish oil at 150 pounds pressure to the gate cylinders. A hand pump will be provided for emergency use. Oil flow to and from the cylinders will be controlled by four-way valves located in the engine room.

H. Crane. - A five-ton overhead crane will be installed in the engine room to facilitate the repairing of any items of equipment. The crane will be of standard construction and hand-operated throughout.

I. Fire extinguishing system. - A carbon dioxide fire extinguishing system will be installed and so arranged that any gasoline engine can be blanketed with gas by tripping a valve located just inside the main entrance to the building. Portable extinguishers will be provided to care for any other emergencies.

J. Heating system. - The heating system will be of the two-pipe, gravity type, consisting of an oil-fired cast iron sectional boiler supplying steam to two unit heaters located at opposite ends of the engine room. The oil burner will be of the automatic pressure atomizing type with constant electric ignition. The boiler will be of the water tube type complete with all accessories. The unit heaters will be of ample capacity to heat the engine room under the coldest weather conditions.

VII. STRUCTURAL DESIGN

VII. STRUCTURAL DESIGN

A. Specifications for structural design. -

1. General. - The structural design of the North Meadows pumping station has been executed in general in accordance with standard practice. The specifications which follow cover the conditions affecting the design of the reinforced concrete and structural steel.

2. Unit weights. - The following unit weights for material were assumed in the design of the structure:

Water	62.5#	per	cubic	foot
Dry earth	100 #	"	"	"
Saturated earth	125 #	"	"	"
Concrete	150 #	"	"	"
Surcharge, where used,	200 #	"	square	"

3. Earth pressures. - For computing earth pressure caused by dry earth Rankine's formula was used. For saturated soils an equivalent liquid pressure of 80 pounds per square foot per feet of depth was assumed.

4. Structural steel. - The design of structural steel was carried out in accordance with the Standard Specifications for Steel Construction for Buildings of the American Institute of Steel Construction.

5. Reinforced concrete. - In general all reinforced concrete was designed in accordance with the "Joint Committee on Standard Specifications for Concrete and Reinforced Concrete" issued in January, 1937.

a. Allowable working stress. - The allowable working stress in concrete used in the design of the pump house structure and conduits are based on a compressive strength of 3,000 pounds per square inch in 28 days.

Lbs. per sq. in.

b. Flexure (f_c). -

Extreme fibre stress in compression. 800

Extreme fibre stress in compression adjacent to supports of continuous or fixed beams or rigid frames 900

c. Shear (v). -

Beams with no web reinforcement and without special anchorage. 40

Beams with no web reinforcement but with special anchorage of longitudinal steel 60

Beams with properly designed web reinforcement but without special anchorage of longitudinal steel. 120

Beams with properly designed web reinforcement and with special anchorage of longitudinal steel 180

Footings where longitudinal bars have no special anchorage 40

Footings where longitudinal bars have special anchorage. 60

d. Bond (u). -

In beams, slabs and one way footings 100

Where special anchorage is provided. 200

The above stresses are for deformed bars.

e. Bearing (f_c).

Where a concrete member has an area at least twice the area in bearing. 500

f. Axial compression (f_c).

Columns with lateral ties. 450

g. Steel stresses. -

	Building	Conduits
Tension.	18000	16000
Web reinforcement.	16000	16000

h. Protective concrete covering. -

Type of members	Minimum cover in inches
Interior slabs	1 1/2
Interior beams	2
Members poured directly against the ground	4
Members exposed to earth or water but poured against forms .	3

For secondary steel, such as temperature and spacer steel, the above minimum cover may be decreased by the diameter of the temperature or spacer steel rods.

B. Basic assumptions for design. -

1. Roof slab. - The roof slab is of reinforced concrete. It is designed to carry the full dead load plus a live load of 40# per square foot of roof surface.

2. Roof beams. - The roof beams are of structural steel encased in concrete fireproofing. They are designed to carry the full dead load, plus the full live load of 40# per square foot of roof surface. In addition to taking up the roof load, these beams, together with the columns to which they are connected, form portal frames which take up wind load and crane thrusts on the building. The end connections are designed to take up all such horizontal loads.

3. Columns. - Structural steel columns in the side walls and end walls of the superstructure take up the direct roof loads as well as

all wind loads on the sides of the superstructure. In addition, the columns in the side walls carry crane brackets which support the crane runway. These columns are designed to carry full live and dead load from the roof; dead load, live load and impact effect from the traveling crane; bending due to eccentrically applied loads, and bending due to wind load on the building. No point of inflection was considered in the column design, a pin-ended condition being assumed.

4. Machinery room floor. - The machinery room floor is designed to carry all engines, motors, etc., actually to be placed on that floor, as well as a uniform load.

The following assumptions were made for design purposes:

a. For the floor slab, the design loads are the estimated dead loads plus a uniform live load of 350# per square foot.

b. For the removable steel floor plates, the design loads are the estimated dead load plus a uniform load of 350# per square foot.

c. For the floor beams, the design loads are the estimated dead loads, the actual machinery loads, a possible floating slab load under the gasoline engine and right angle gear units, and a uniform load of 250# per square foot on the unoccupied portion of the floor slabs which contribute loads to the beams under consideration. For the machinery loads and the floating slab load, an impact factor of 100 per cent has been added.

5. Pump room side walls and floor slab. -

a. In designing the pump room side walls and floor slab the assumption was made that the side walls are simply supported at the top edges and continuous with the floor slab at the bottom. This assumption seems reasonable in view of the fact that the machinery floor slab is only 8 3/4 inches thick and the machinery floor beams do not provide continuous wall support. The floor beams do, however, serve as stiffeners for the slab and help the latter to take up the thrust from the side walls. Actually, the floor beams will take up a part of the wall thrusts and will thereby provide an added factor of safety.

b. The loading on the frame formed by the pump room side walls and floor slab consists of the vertical load from the superstructure, including full live load on the roof; the vertical loads from the machinery room floor; the vertical loads on the floor slab from the pumps and that brought down by the side walls; and the thrusts against the side walls, made up of direct earth pressure plus horizontal reactions brought against the side walls by the conduit roof and floor slabs due to earth pressure on the outer conduit walls.

From the loadings noted, bending moments were computed in the side walls and pump room floor slab, the bending moments in the side walls being adjusted for additional moments due to the side walls also serving as conduit walls.

6. Pump room end walls. - The pump room end walls are designed to resist the vertical load plus the thrusts from earth pressure in the case of the east wall, and for a hydrostatic pressure only in case of the west wall.

7. Gravity flow conduit adjacent to pump room. - That part of the gravity flow conduit which is attached to the pump room, with one wall

common to both the conduit and the pump room, is designed for an external roof slab load equal to the dead weight of roof slab; weight of earth fill; a live load surcharge of 200# per square foot; an external floor slab load equal to the net soil reaction; and an external side wall pressure which varies with the depth. For the condition of external loading the assumption was made that the conduit was unwatered.

The conduit was also investigated for internal hydrostatic pressures due to an assumed rise of the river to Elevation 45.0.

8. Gravity flow conduit intake. - The gravity flow conduit intake is an extension of the gravity flow conduit into the storage pond. It is roofed over for approximately seven feet beyond the building by a continuation of the conduit roof slab and is open on top from there to the end. It is 17'-0" long. Stop log slots are provided at 4'-6" from the building and also at the open end of the intake. In designing the open part of the intake, the assumption was made that stop-logs would be in place at the end and that the water in the storage pond would be at an elevation equal to the top of the stop-logs. The side walls and floor slab were made continuous with each other and were designed for full hydrostatic pressure on the structure. The floor of the intake was shaped to suit hydraulic requirements.

9. Suction conduit. - The suction conduit is attached to the south wall of the pump house, one wall being common to the pump room and to the conduit. It is designed for an external roof slab load equal to the dead weight of slab; weight of earth fill; a live load surcharge of 200# per square foot; an external floor slab load equal to the net soil

reaction; and external side wall pressure which varies with the depth. The conduit was assumed unwatered. No internal hydrostatic pressures were considered.

10. Suction conduit intake. - The suction conduit intake, like the gravity flow conduit intake, extends into the storage pond 17'-0" from the building. The suction intake was designed for the same external loading assumptions as was the gravity flow conduit intake, the hydrostatic loads, however, being much greater because of the greater depth of the suction intake. The intake is provided with a concrete apron at the open end and raking platform 5'-0" wide next to the building. The underside of the raking platform is curved to suit hydraulic requirements. In designing the suction intake, it was assumed that the side walls and bottom slab at the apron were continuous with each other and simply supported at the apron; that the sidewalls and bottom slab at the raking platform formed a continuous box section with the raking platform; and that the portion of the intake between the apron and the raking platform consisted of side walls continuous with the bottom slab and simply supported by horizontal beams spanning from apron slab to raking platform.

11. Gravity flow conduit from pump house to outlet gate structure. - Because of variations in loading, the gravity flow conduit between the pumping station and the outlet gate structure was divided into three sections for purpose of design. The first section extends from the pump house to the foot of the dike; the second section extends from the foot of the dike to a point half way to the top of the dike; the third section extends from a point half way to the top of the dike to a corresponding

point on the opposite slope. The section of the conduit from this last point to the outlet gate structure was designed like the second section previously mentioned. All three sections were designed as continuous closed structures, the first section as a single box, the second and third sections as double boxes with center walls. Copper water stops are provided at all field and expansion joints. To reduce seepage of water along the outside surfaces of the conduit, seven reinforced concrete seep rings are cast integrally with the conduit. The seep rings extend 3'-0" above and below the top and bottom slabs of the conduit respectively, and extend outward from the sides a distance which varies from 3'-0" at the top of each ring to about 5'-0" at the underside of the floor slab. The rings are 1'-6" thick at the top and flare out each way toward the bottom on a slope of 1 on 8. A steel sheet pile cut-off wall is cast into the first seep ring nearest the outlet end. Because of the compressibility of the soil and variable loading on the portion of the conduit under the dike, a vertical camber of 3 inches is called for in this part of the conduit. It is assumed that this camber will be taken out as the dike is built up over the conduit.

12. Outlet structures. -

a. Sluice gate structure. - At the discharge end, the conduit terminates in a reinforced concrete outlet sluice gate structure. A chamber in which the sluice gate will be normally housed is located above the top of the conduit. In emergencies or during conduit repairs, these gates will be lowered to close the outlet openings. Access to the chamber is through a manhole in the chamber roof slab. The manhole cover contains air escape openings, permitting the water to fill the gate chamber during high river stages without subjecting it to unbalanced pressures. To allow for possible ice thrusts the outlet sluice gate structure was investigated for the condition of a thrust at its top of 1,000 lbs. per linear foot of wall parallel to the river.

b. Outlet apron. - The outlet end of the conduit is protected by a reinforced concrete apron with side walls which extends 12 feet beyond the outlet sluice gate structure. This structure was designed for a saturated earth pressure of 80# per square foot per foot of depth exerted simultaneously against both walls.

c. Outlet wing walls. - From the end of the apron, wing walls are extended into the riprapped fill on each side of the outlet channel. The walls are stepped at their base to allow for the rise of the embankment. They were designed for the condition of saturated earth pressure. Drainage for the wing walls is obtained by means of a layer of broken stone and clay tile drains which will carry the drainage water around the downstream ends of the walls and into the outlet channel.

13. Wing walls at intake end. - Wing walls at the intake end of the pumping station are provided to hold back the earth fill against the sides of the building. The tops of the wing walls follow the tops of the fills, sloping where the fills are sloped. The walls were designed on the assumption of a saturated earth to Elevation 15.0 and dry earth without surcharge from Elevation 15.0 to Elevation 19.0.

14. Stairways and walkways. -

a. Access stairs to pump room. - The earth fill at the north and south sides, and at the east end will be placed to Elevation 18.5. The west end will face the storage pond. Access to the pump room, the floor of which is approximately at Elevation -5.0 is therefore obtained through a stairway opening in the floor located near the northwest corner. The stairway from Elevation 19.0 to Elevation 10.0 and the stairway landing at Elevation 10.0 are of reinforced concrete. A 6-inch reinforced concrete partition wall closes off this stairway from the rest of the pump room, entrance to the pump room being obtained through a door in the partition. The purpose of the partition enclosure is to prevent air drafts into the machinery room above.

b. Pump room stairs and walkways. - A steel grating walkway meets the stairway landing at Elevation 10.0. This walkway leads to the boiler room and also to a grating stairway at the west end which descends to Elevation 0.75. Steel grating walkways follow along the west and south walls. Stairways from the walk on the south side lead down to the pump room floor. The walkways and pump room stairways were designed for the estimated dead load plus a live load of 50 lbs. per square foot.

15. Trash rack. -

a. Trash racks for gravity flow intake. - For the gravity flow intake a rack in one piece is provided. It is 8'-5" deep and 16'-6" wide and consists of a welded structural steel channel frame which supports 15'-4" x 5/8" bars spaced 1'-0" in the clear. Each bar has one rounded edge towards the pond and is welded to the channel frame at its other edge with 3/8-inch fillet welds at all intersections. The frame fits into slots in the side walls of the intake structure and into an angle recess in the floor slab. It weighs 2,440 lbs.

b. Trash rack for suction flow intake. - The trash rack for the suction intake is made up of four sections. Each section is 3'-10 1/2" wide and 14'-9" deep and consists of a welded channel frame to which are welded eight 4" x 5/8" bars spaced 4 inches in the clear. Each bar has one rounded edge towards the pond and is welded to the channel frame at its other with 3/8-inch fillet welds at all intersections. The frames are placed alongside each other so as to screen the entire inlet opening. They are supported at the bottom by an angle recess in the intake floor slab; at their mid-point vertically by a 10-inch wide-flange guide beam set into the intake side walls; and at their tops by the raking platform. A steel plate set into the rounded raking platform edge will prevent injury to the concrete from abrasion and from possible blows by the racks whenever these are hoisted up for painting or other maintenance purposes. The 10-inch wide-flange guide beam will serve a similar purpose. Each rack section weighs 1,860 lbs.

c. Trash rack loadings. - The design of the racks was not based on actual loadings since these, even for the most severe conditions, would require only small sections. Sections were therefore chosen which would provide ample rigidity and proper thickness against corrosion.

C. Architecture. -

1. Pumping station. - The pumping station will be a building of modern design in keeping with the architectural treatment used on similar projects elsewhere on the Connecticut River. This design will give a pleasing appearance without undo emphasis being placed on purely decorative features.

The pumping station will be a flat-roofed, brick and glass block structure 27 feet by 69 feet inside. The 13-inch thick brick walls, capped with a cast stone coping, extend above the roof slab to form a parapet wall around the entire roof. A flat type roof was chosen as being economical and in keeping with the architectural design, as well as serving as a location for the engine exhaust mufflers. The roof system consists of steel beams encased in concrete and supported by steel columns. The roof slab will be 4 3/4 inches thick, covered with a sawdust concrete fill sloped to drain. There are no outside pilasters except at the chimney. Inside the building there are pilasters at the chimney and at each structural steel column, the pilasters forming fire-proof column encasements. Additional pilasters are provided where necessary for the encasement of the gasoline engine exhaust pipes. The engine room floor will be a 3-inch granolithic fill over the structural concrete floor slab, a depth of 3 inches being made necessary by the size of the ducts and pipes which must be encased in the floor fill. A hand-operated traveling crane of 5 tons lifting capacity will operate for the full length of the building and will be used for installing and moving pumps and machinery. Access for the crane hoist to the pump room will be had through two 7' x 11' openings in the machinery room floor, these openings being normally covered with removable checkered floor plates.

There is no window sash in the building. Light will be admitted through large glass block panels, glass blocks being chosen in preference to sash because of the exposed location of the pumping station near the river banks. The well-diffused and uniform light which they provide and their appearance is also in keeping with the spirit of the architectural design. To provide ventilation, movable louvres have been placed low in the brick walls and a motor operated exhaust ventilator has been placed on the roof.

Two doors give access into the building. The main entrance door, 7'-5" wide by 10' high consists of two leaves of hollow steel construction and gives entrance directly to the machinery room floor. It is large enough to provide adequate clearance for any replacement of mechanical equipment which may be required in the future. The small hollow steel door on the north side of the building provides a service entrance into the station as well as a direct route from the inside of the building to the trash rack raking platforms, either by means of the steel rung ladder on the face of the west wall or by means of the ramp around the end of the wall.

2. <u>Outlet sluice gate structure.</u> - No attempt was made at elaborate architectural treatment of the outlet sluice gate structure. The exterior faces of the walls have been divided into panels and enough architectural treatment provided to relieve the walls of monotony.

VIII. CONSTRUCTION PROCEDURE

VIII. CONSTRUCTION PROCEDURE

A. Sequence of operations. - It is expected that the pumping station, conduit and outlet structure will be completed in 250 calendar days after receipt by the contractor of notice to proceed. The schedule of work will require the contractor to complete that portion of the outlet conduit which passes under the dike and the gate house at the river end of the outlet conduit, together with the installation of the sluice gates in the gate house, within 85 calendar days after receipt by the contractor of notice to proceed, and to complete all work within the 250 calendar days noted above.

B. Construction period. - A study of hydrographs plotted from data recorded by the United States Weather Bureau from 1917 to 1938, a total of 22 consecutive years, shows that the majority of the floods at Hartford occur in the spring months of March, April, and May. The site of the pumping station is at Elevation 12.0 to 14.0 m.s.l. and has been flooded at least once in almost every year recorded. It is noted, however, that between May 20th and December 1st the peak has reached Elevation 14.0 only six times, as follows:

Date	Elevation of high water
May 25, 1919	19.0
June 25, 1922	15.0
November 8, 1927	29.2
June 10, 1931	18.0
November 25, 1932	18.0
September 23, 1938	35.4

Consideration of this matter including a study of the above table leads to the conclusion that if work on the pumping station begins after May 20th, protection to Elevation 18.0 will probably be sufficient. To take advantage of the period of low floods it is planned to award the contract for the construction of the pumping station so that actual work may be started not later than April 20th and to have the whole contract completed not later than December 1st. The contractor will be responsible for all damage by floods to Elevation 18.0 while the Government will be responsible for damage by floods which may exceed Elevation 18.0, the contractor being required to repair all such damage at contract unit prices. It is proposed to have the work carried out approximately in accordance with the following construction schedule:

Designation	Quantity: Cu. Yds.	Time Limits of Operation	No. of Working Days	Daily rate of construction Cu. Yds.	Remarks
Conduit excavation	6,000	April 20-May 30	30	200	(Conduit to (be completed for (diversion (and dike (construction July 15.
Concrete in conduit and outlet	1,500	May 10 - June 20	30	50	
Backfill of conduit	3,000	June 20-July 15	20	150	
Delivery of equipment		August 1			
Excavation for building and pond	6,700	April 20-Aug.15			
Concrete in bldg.	1,500	June 15-Aug. 15	50	30	
Completion of building brick work		September 15			
Completion of superstructure		October 15			
Installation of mechanical equipment		November 15			
Job completed		December 1, 1939			

C. Installation of equipment. - The equipment in the boiler room and the electrical and mechanical equipment on the machinery room floor at Elevation 19.0 will not be installed before the dike is completed to Elevation 30.0. The contract must be completed within 60 days after permission to install this equipment has been given, plus any extension of time that may be granted.

D. Concrete construction. -

1. Composition of concrete. - The concrete will be composed of cement, fine aggregate, coarse aggregate, and water so proportioned and mixed as to produce a plastic, workable mixture. All concrete will be Class "A," as designated in the specifications, and will have an average compressive stress of not less than 3,000 lbs. per square inch, in accordance with a standard 28-day test. Concrete aggregates will have to be of suitable quality and will be tested by the Central Concrete Testing Laboratory at West Point.

2. Laboratory control. - A small concrete testing laboratory will be set up at the site to be used principally to control the quality of concrete during construction. The tests performed here will supplement those made at the Central Laboratory. Facilities will be available for testing the grading of aggregates, designing concrete mixtures, mixing of trial concrete batches for the purpose of developing actual relations between compressive strength and water cement ratio, controlling workability of concrete by slump tests, and casting of concrete cylinders for compressive strength tests.

a. Cement. - Cement will be tested by a recognized testing laboratory and results of these tests shall be known before the cement is used. True Portland cement of a well-known and acceptable brand will be used throughout.

b. Fine aggregate. - Natural sand will be used as fine aggregate. The aggregate will be subject to careful, thorough analysis, including magnesium sulphate soundness tests, and tests made on mortar specimens for compressive strength.

c. Coarse aggregate. - Washed gravel or crushed stone of required sizes will be used as coarse aggregate. It must consist of hard, tough and durable particles free from adherent coating and must be free from vegetable watter. Only a small amount of soft, friable, thin or elongated particles will be allowed. The aggregate will be subject to freezing and thawing tests and to careful, thorough analysis, including magnesium sulphate tests for soundness.

d. Water. - The amount of water used per bag of cement for each batch of concrete will be predetermined; in general, it will be the minimum amount necessary to produce a plastic mixture of the strength specified. Slump tests will be required in accordance with specifications.

3. Field control. -

a. Storage. - The concrete components will be stored in a thoroughly dry, weather-tight, and properly ventilated building. The fine and coarse aggregates will be stored in such manner that inclusion of foreign material will be avoided.

b. Mixing. - The exact proportions of all materials in the concrete will be predetermined. The mixing will be done in approved mechanical mixers of a rotating type, and there must be adequate facilities for accurate measurement and control of each of the materials used in the concrete. Mixing will be done in batches of sizes as directed and samples will be taken for slump tests and for compressive strength tests. Inspectors will at all times supervise and inspect the mixing procedure.

c. Placing. - Concrete will be placed before initial set has occurred. Forms will be clean, oiled, rigidly braced and of ample strength. Concrete poured directly against the ground will be placed on clean damp surfaces. Mechanical vibrators will be used, and forking or hand-spading will be applied adjacent to forms on exposed surfaces to insure smooth, even surfaces. Location of vertical and horizontal construction joints, as well as contraction and expansion joints and location of copper water stops, are indicated on the drawings. The locations of construction joints are tentative and may be changed to suit conditions in the field. Before placing concrete, all reinforcing steel will be inspected and pouring of the concrete will be supervised and directed by Government inspectors. Adequate precautions will be taken if concrete is to be placed in cold or hot weather.

E. Structural steel construction. - Structural steel construction consists of the framework for the superstructure; the walkways and stairway in the pump room; the steady beams for the pump shafts; the trash racks; and the miscellaneous frames, angles, checkered plates, crane rails, railings, and ladders.

1. Superstructure framework. - The superstructure framework consists of beams and columns which will form a skeleton frame for the

exterior walls and roof, and will provide a runway for the hand-operated crane. The columns will be securely anchored to the substructure concrete walls and will be connected to the roof beams with web connection angles and wind bracing connections. The crane rails will be fastened to the crane runway beams with bent hook bolts. Crane stops at each end of the runway will prevent the traveling crane from running into the end walls.

2. Walkways and stairways. - The grating for the walkways and stairway treads in the pump room will be supported on structural steel channels carried on double angle columns anchored to the pump room floor and on steel channels anchored to the pump room walls. Wrought-iron pipe railings are to be fastened to curb plates on the outside channel stringers and to the top flanges of the stairway channels.

3. Steady beams. - The steady beams consist of two channels each, their flanges connected with lattice bars and batten plates. The pump shafts will pass through an opening between the middle batten plates and will be supported sidewise by bearings bolted to the top batten plates. Holes for bolting the bearings to the steady beams will be drilled in the field. The steady beams will be bolted to the substructure side walls with four 1-inch anchor bolts at each end. To obtain a firm bearing against the walls, the connection angles and bearing plate at one end of the steady beams will be shipped to the site loose with holes punched in the angles. Matching holes in each steady beam will be drilled in the field after each beam has been firmly shimmed against the pump room walls. The steady beams are designed to take a side-thrust of 1,000 lbs. applied at the shaft bearing.

4. Trash racks. - The trash racks are made up of structural channel frames which support 4" x 5/8" grating bars. The bars for the gravity flow intake are spaced 12 inches in the clear while those for the suction intake are spaced 4 inches in the clear. The racks are welded throughout.

5. Removable floor plates. - Access for the crane to the pump room will be obtained by removing checkered floor plates which cover two 7' x 11' openings in the machinery room floor. The removable covers consist of 1/4-inch checkered plates welded to the top flanges of 3-inch I-beams the ends of which are supported on angle frames anchored into the floor concrete. Each opening in the floor is covered with 3 sections. Lifting rings are provided in the plates for easy removal.

6. Miscellaneous angles and frames. - Miscellaneous structural steel such as door frames, angles, grilles, etc., will be erected and placed as indicated on the drawings and at such time as required.

IX. SUMMARY OF COST

IX. SUMMARY OF COST

The total construction cost of the North Meadows pumping station, including the conduit outlet gate house, pond excavation to 62 feet beyond the building line, and mechanical equipment, has been estimated to be $259,000, including 15 per cent for engineering and 10 per cent for contingencies.

This amount has been distributed as follows:

(1) Pumping station. -			
	a. Concrete features	$47,000	
	b. Superstructure.	15,000	
	c. Miscellaneous	18,000	$ 80,000
(2) Conduit. -			
	a. Concrete features	$51,000	
	b. Miscellaneous	18,000	69,000
(3) Mechanical equipment			110,000
		TOTAL	$259,000

(1) a. The concrete features included under the pumping station item (1) a. consist of intake structures, building foundation to and including operating floor structural slab, suction intake and gravity conduit adjacent to the building.

(1) b. The superstructure consists of the complete building above the operating floor including the 3-inch granolithic fill.

(1) c. Miscellaneous items are pond excavation to 62 feet beyond the pumping station, common excavation and backfill, miscellaneous iron

and steel, trash racks, and other items not included in (1) a and (1) b.

(2) a. The concrete features included under the conduit item (2) a consist of the conduit with seep rings, the outlet gate house, and wing walls.

(2) b. Miscellaneous items are common excavation and backfill, riprap, permanent steel sheet piling, and 8-inch vitrified clay pipe drains.

(3) The mechanical equipment consists of pumps, gas engines, gear units, crane, generating units, valves and piping, sluice gate system, and miscellaneous items.

PLATES

ANALYSIS OF DESIGN

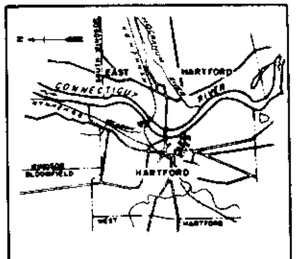
NORTH MEADOWS PUMPING STATION

INDEX FOR PLATES

Plate No. 1	Project location and index
Plate No. 2	Hydrograph No. 1
Plate No. 3	Hydrograph No. 2
Plate No. 4	Subsurface exploration
Plate No. 5	Pond layout
Plate No. 6	General plan
Plate No. 7	Outlet conduit profile and excavation details
Plate No. 8	Sections, roof plan and details
Plate No. 9	General arrangement of equipment No. 1
Plate No. 10	General arrangement of equipment No. 2
Plate No. 11	General arrangement of equipment No. 3
Plate No. 12	Stage-duration curve of Connecticut River at pumping station outlet
Plate No. 13	River stage versus required discharge capacity
Plate No. 14	Output of pumps
Plate No. 15	Organization chart

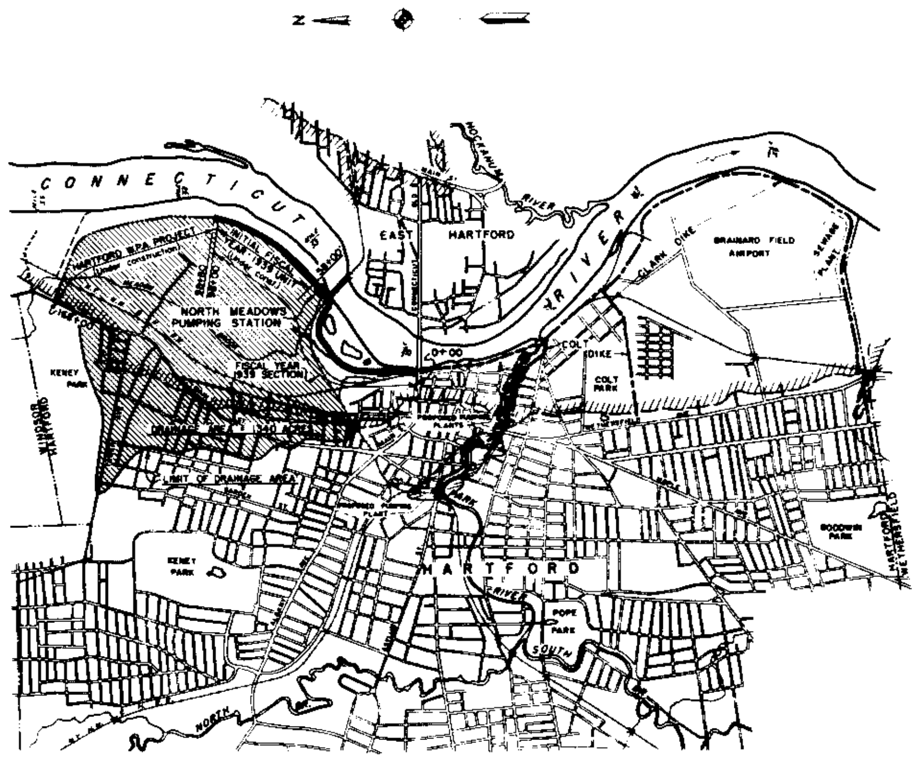
WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY.



VICINITY MAP

SCALE 1IN. = 2MI.



LEGEND

Fiscal Year 1939 Section, Dike Contract	
Hartford-W.P.A. Project	
Present Dike	
Future Construction	
Overflow Limits of the March 1936 Flood	

NOTE

Initial Fiscal Year 1939 Unit designates limits of steel sheet piling under construction.

NOTE:
ELEVATIONS REFER TO MEAN SEA LEVEL DATUM EXCEPT HYDROGRAPH SHEETS NOS. 2 AND 3.

DATE	REVISION	REV.BY	CK.BY	AP.BY

CONNECTICUT RIVER FLOOD CONTROL

NORTH MEADOWS PUMPING STATION

FISCAL YEAR 1939 SECTION

PROJECT LOCATION AND INDEX

HARTFORD, CONN.

CONNECTICUT RIVER CONNECTICUT

IN 59 SHEETS SCALE 1IN = 2000FT. SHEET NO. 1

2000' 0 2000' 4000'

U. S. ENGINEER OFFICE, PROVIDENCE, R.I., FEB. 1939

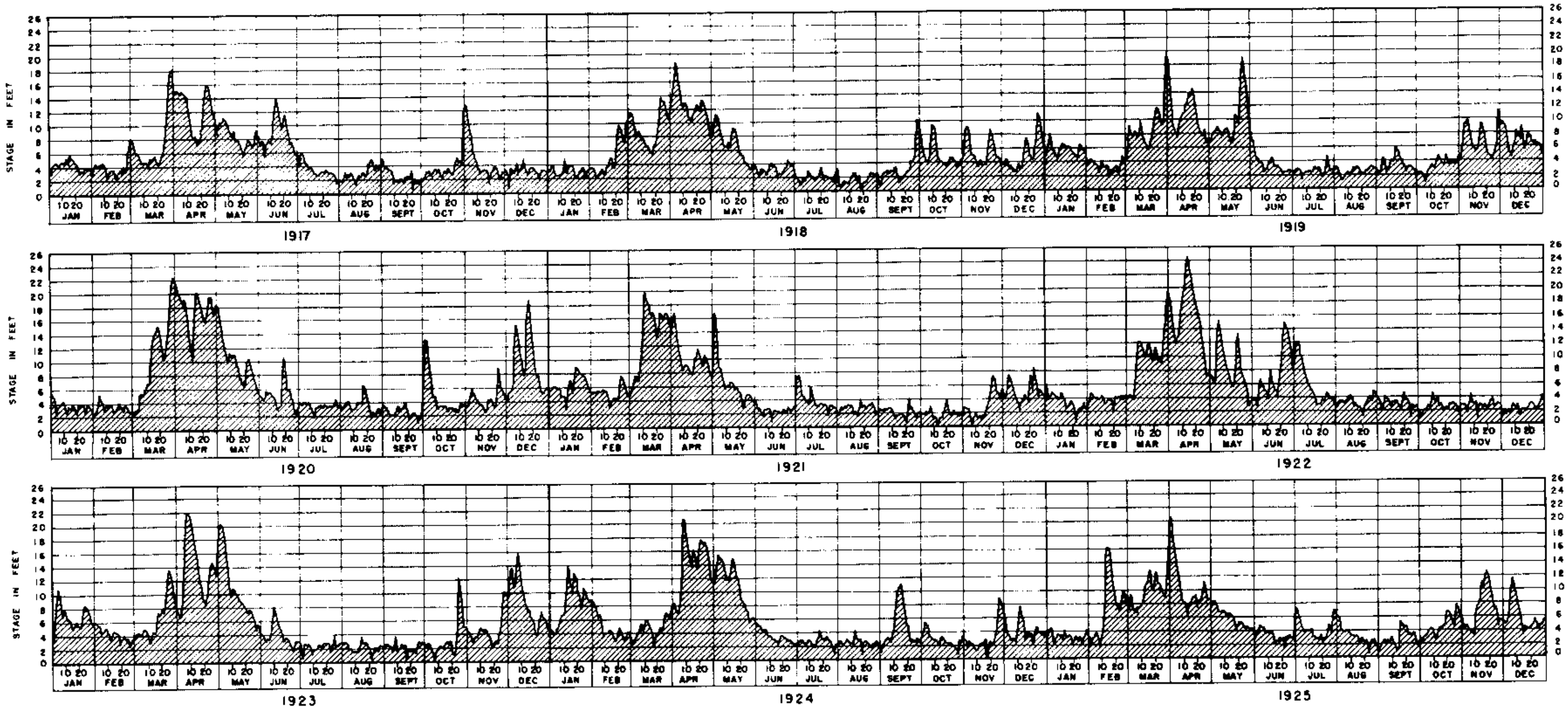
SUBMITTED: SENIOR ENGINEER, HEAD, DESIGN SECTION — RECOMMENDED: PRINCIPAL ENGINEER, CHIEF, F.C. ENGINEERING DIV. — APPROVED: DISTRICT ENGINEER

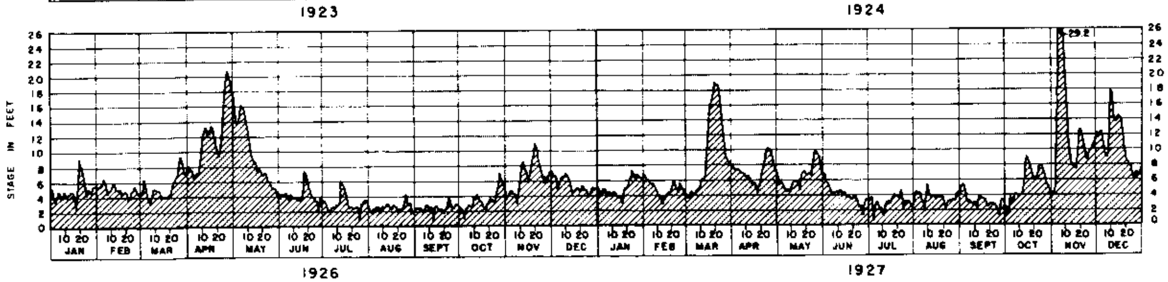
DESIGNED: ASSOC. ENGINEER — DRAWN BY E.J.H. TRACED BY A.S. CHECKED BY — FILE NO. CT-4-1252

PLATE NO. I

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY.





STAGE IN FEET	EL.-FEET ABOVE M.S.L.
10.00	9.45
5.00	4.45
+0.55	0.00
0.00	-0.55

STAGE-ELEVATION RELATION

NOTES:

Low stages are subject to tidal fluctuation which has a mean amplitude 0 at a stage of 7 feet and 1.5 feet at a stage of 2 feet.

Stage readings on Hartford gage, zero=-0.55 M.S.L.

Data supplied by U.S. Weather Bureau.

Gage located on downstream side of Memorial Bridge (Connecticut Boulevard).

DATE	REVISION	REV.BY	CK.BY	AP.BY

CONNECTICUT RIVER FLOOD CONTROL

NORTH MEADOWS PUMPING STATION

FISCAL YEAR 1939 SECTION

HYDROGRAPH NO. I.

HARTFORD, CONN

CONNECTICUT RIVER — CONNECTICUT

IN 59 SHEETS — SCALE AS SHOWN — SHEET NO. 2

U.S. ENGINEER OFFICE, PROVIDENCE, R.I., FEB. 1939

SUBMITTED: ENGINEER, HEAD, HYDRAULICS SECTION — APPROVAL RECOMMENDED: PRINCIPAL ENGINEER, CHIEF, F.C. ENGINEERING DIV. — APPROVED: LT. COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

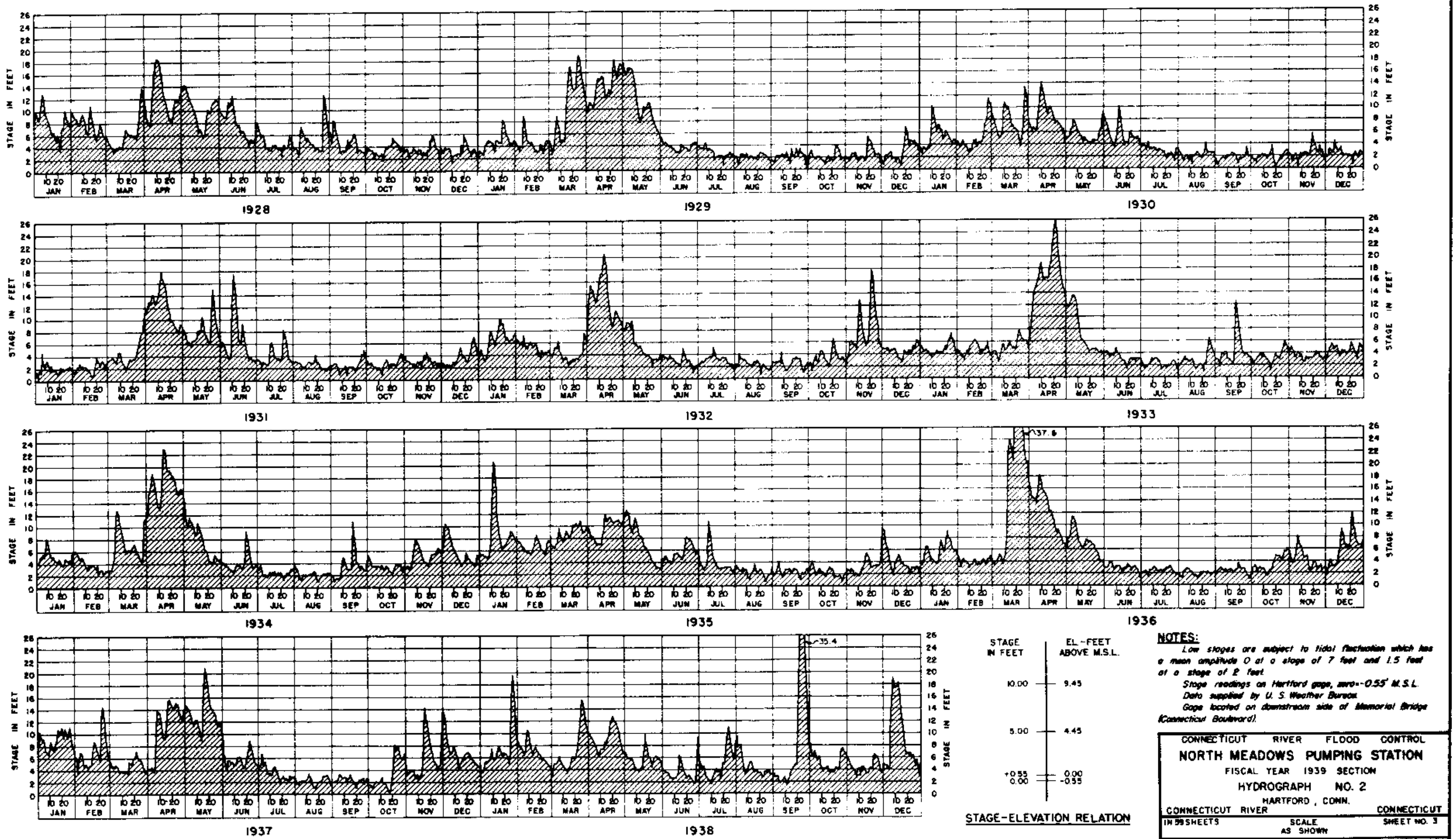
COMPILED: ASS'T ENGINEER — DRAWN BY: W.W.V. & F.C.T. — TRACED BY: F.J.B. — CHECKED BY:

FILE NO. CT-3-1089

PLATE NO. 2

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY



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Gage located on downstream side of Memorial Bridge (Connecticut Boulevard).

DATE	REVISION	REV. BY	CK. BY	AP. BY

CONNECTICUT RIVER FLOOD CONTROL

NORTH MEADOWS PUMPING STATION

FISCAL YEAR 1939 SECTION

HYDROGRAPH NO. 2

HARTFORD, CONN.

CONNECTICUT RIVER — CONNECTICUT

IN 59 SHEETS — SCALE AS SHOWN — SHEET NO. 3

U.S. ENGINEER OFFICE, PROVIDENCE, R.I., FEB. 1939

SUBMITTED: [illegible] ENGINEER, HEAD, HYDRAULICS SECTION

APPROVAL RECOMMENDED: [illegible] PRINCIPAL ENGINEER, CHIEF, F.C. ENGINEERING DIV.

APPROVED: [illegible] LT. COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

COMPILED: [illegible]

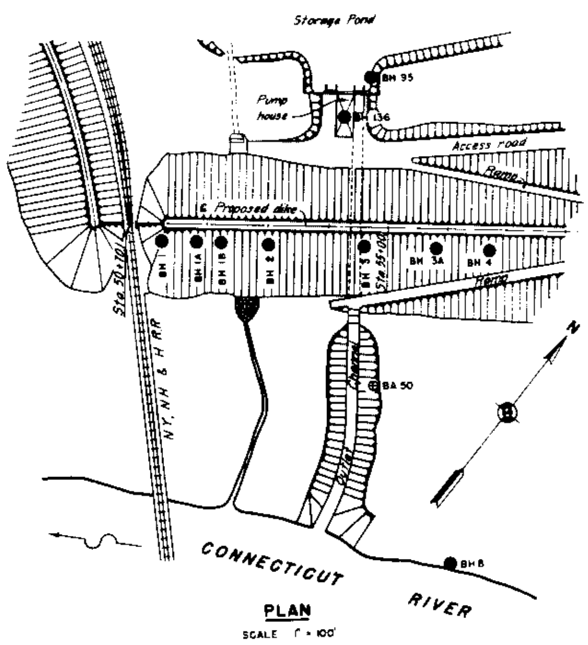
DRAWN BY: H.W.V. & F.C.T.
TRACED BY: H.W.B.
CHECKED BY:

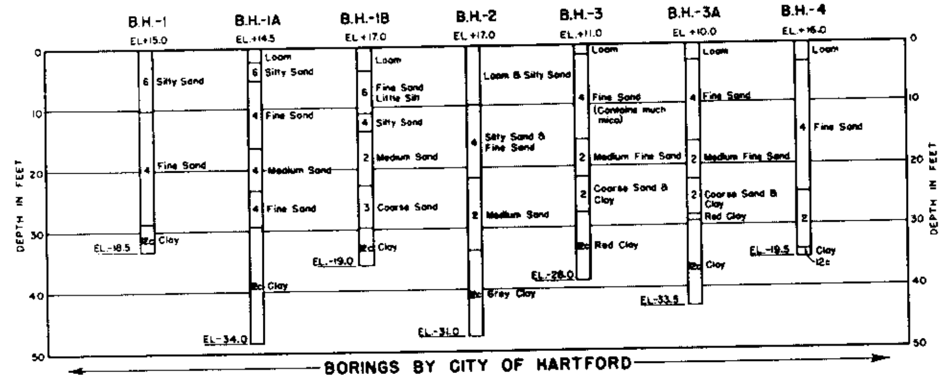
FILE NO. CT-3-1090

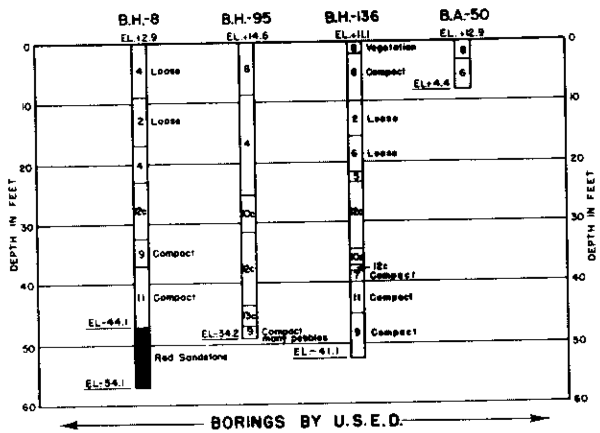
PLATE NO. 3

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY







LEGEND:

● BH - *Drive sample bore hole.*
⊕ BA - *Auger boring*

NOTES:

Elevations refer to M.S.L. Datum.
Soil samples from Hartford borings classed visually by Providence District. Abbreviated description of materials furnished by City of Hartford.

DESCRIPTION OF NUMERICAL CLASSES

[1] Clean Gravel- Contains little coarse to medium sand.

[2] Uniform Coarse to Medium Sand-Contains little gravel and fine sand

[3] Variable-Graded from Gravel to Medium Sand-Contains little fine sand.

[4] Uniform Medium to Fine Sand-Contains little coarse sand and coarse silt

[5] Variable-Graded from Gravel to Fine Sand-Contains little coarse silt.

[6] Uniform Fine Sand to Coarse Silt-Contains little medium sand and medium silt.

[7] Variable Graded from Gravel to Coarse Silt-Contains little medium silt.

[8] Uniform Coarse to Medium Silt-Contains little fine sand and fine silt.

[9] Variable-Graded from Gravel to Medium Silt-Contains little fine silt.

[10] Uniform Medium to Fine Silt-Contains little coarse silt and coarse clay. Possesses behavior characteristics of silt.

[10c] Uniform Medium Silt to Coarse Clay-Contains little coarse silt and medium clay. Possesses behavior characteristics of clay.

[11] Variable-Graded from Gravel or Coarse Sand to Fine Silt-contains little coarse clay.

[12] Uniform Fine Silt to Medium Clay-Contains little medium silt and fine clay (colloids). Possesses behavior characteristics of silt.

[12c] Uniform Clay-Contains little silt. Possesses behavior characteristics of clay.

[13] Variable-Graded from Coarse Sand to Clay-Contains little fine clay (colloids). Possesses behavior characteristics of silt.

[13c] Variable Clay-Graded from sand to fine clay (colloids). Possesses behavior characteristics of clay.

DATE	REVISION	REV BY	CK BY	AP BY

CONNECTICUT RIVER FLOOD CONTROL
NORTH MEADOWS PUMPING STATION
FISCAL YEAR 1939 SECTION
SUBSURFACE EXPLORATION
HARTFORD, CONN.

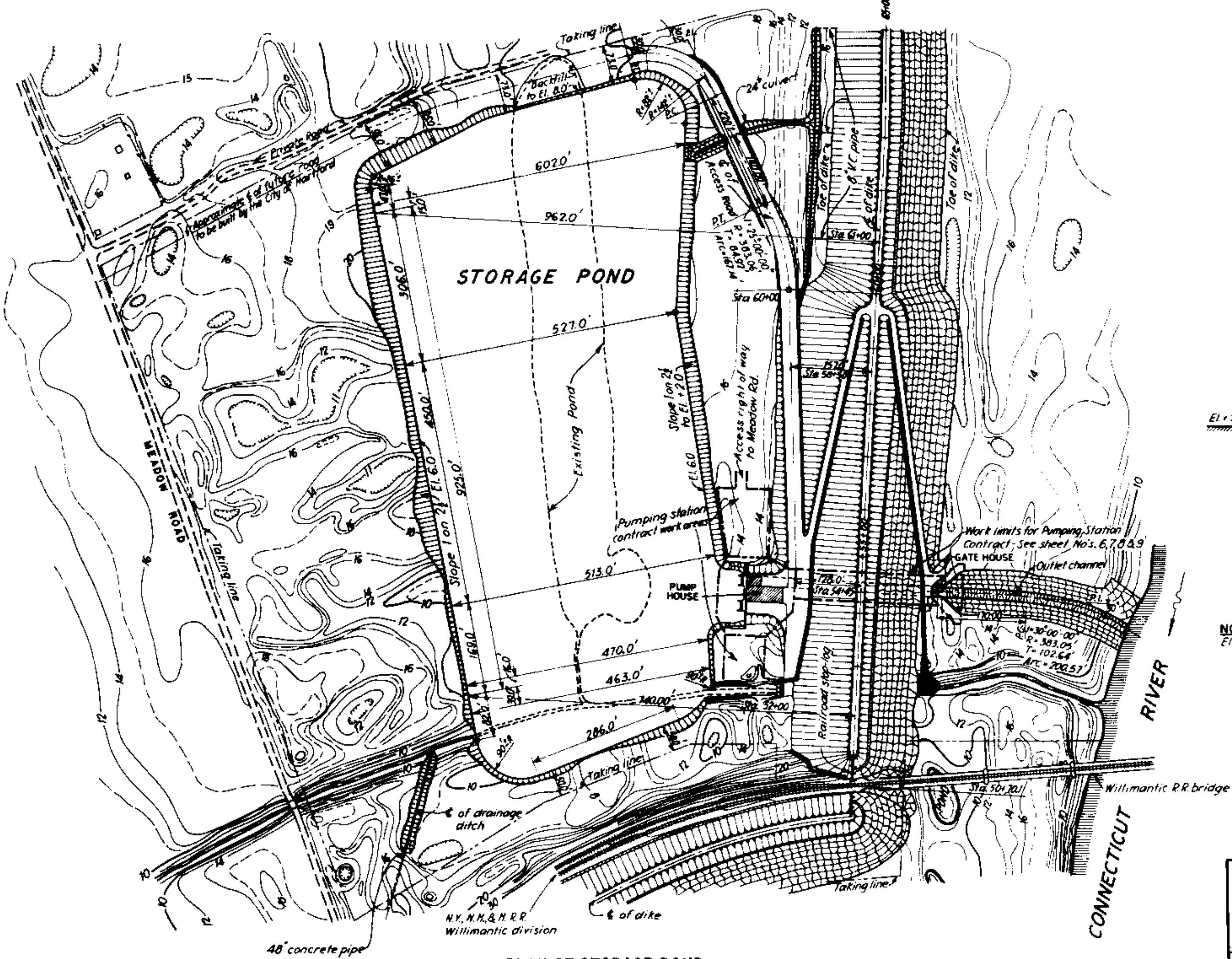
CONNECTICUT RIVER — CONNECTICUT
IN 59 SHEETS — SCALE: 1 IN. = 100 FT. — SHEET NO. 4
U.S. ENGINEER OFFICE, PROVIDENCE, R.I. — FEB. 1939

SUBMITTED: Frank E. Fahlquist, GEOLOGIST, HEAD, GEOLOGY SECTION
APPROVAL RECOMMENDED: T. D. Burns, PRINCIPAL ENGINEER, CHIEF, F.C. ENGINEERING DIV.
APPROVED: LT. COL., CORPS OF ENGINEERS, DISTRICT ENGINEER
COMPILED: ENGINEER
DRAWN BY: E.F.L.
TRACED BY: M.E.L.
CHECKED BY: P.H.L.
FILE NO. CT-2-1147

PLATE NO. 4

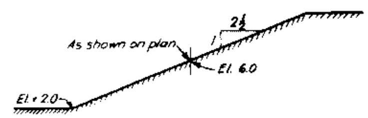
WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY



PLAN OF STORAGE POND

SCALE 1" = 100'



TYPICAL SLOPE SECTION FOR POND EXCAVATION

SCALE 1" = 5'-0"

NOTE: Elevations refer to mean sea level datum

DATE	REVISION	REV. BY	AP. BY	CK. BY

CONNECTICUT RIVER FLOOD CONTROL

NORTH MEADOWS PUMPING STATION

FISCAL YEAR 1939 SECTION

POND LAYOUT

HARTFORD, CONN.

CONNECTICUT RIVER — CONNECTICUT

IN 59 SHEETS — SCALE 1 IN. = 100 FT — SHEET NO. 5

U.S. ENGINEER OFFICE, PROVIDENCE, R.I. — FEB. 1939

FILE NO. CT-4-1253

PLATE NO. 5

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY

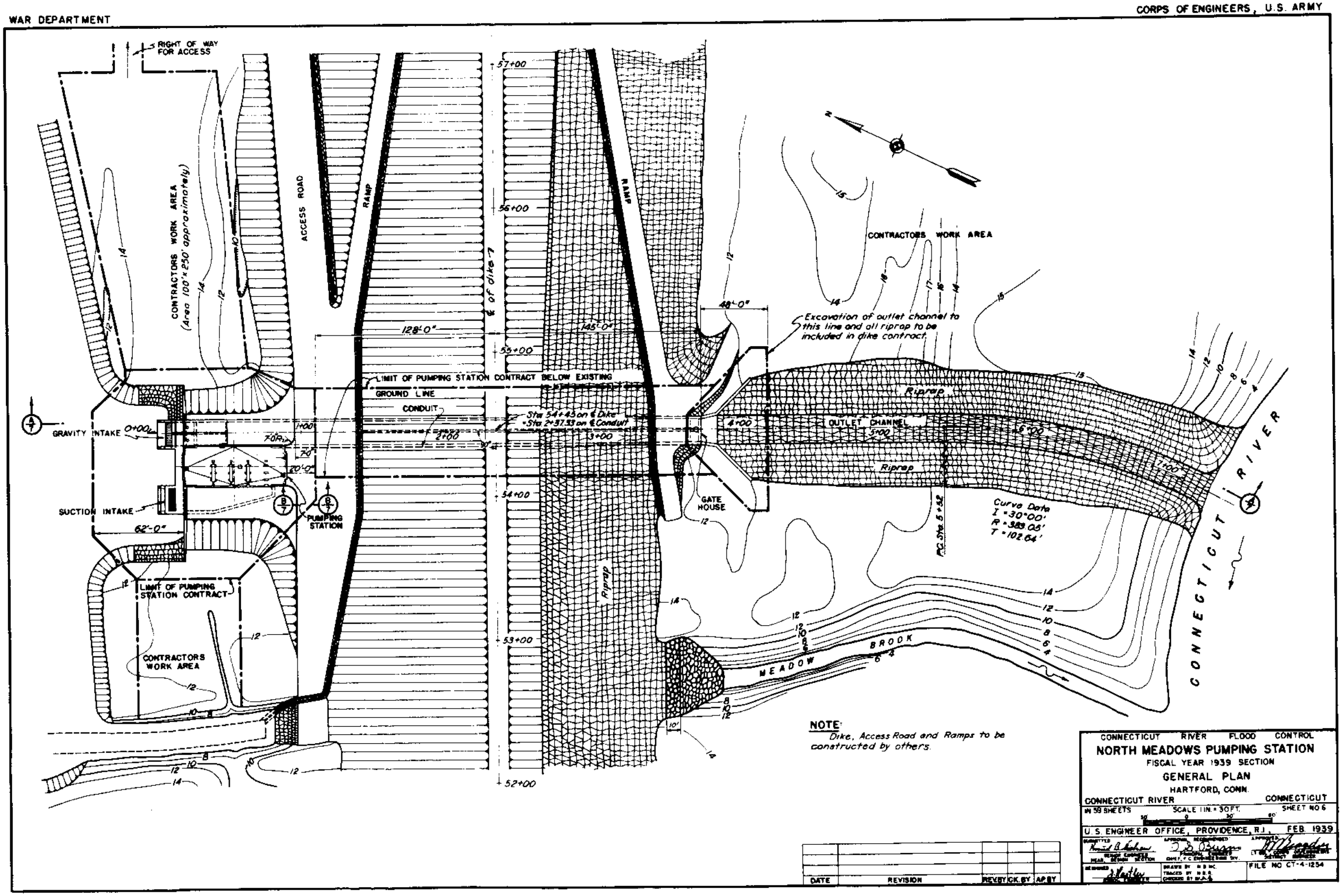
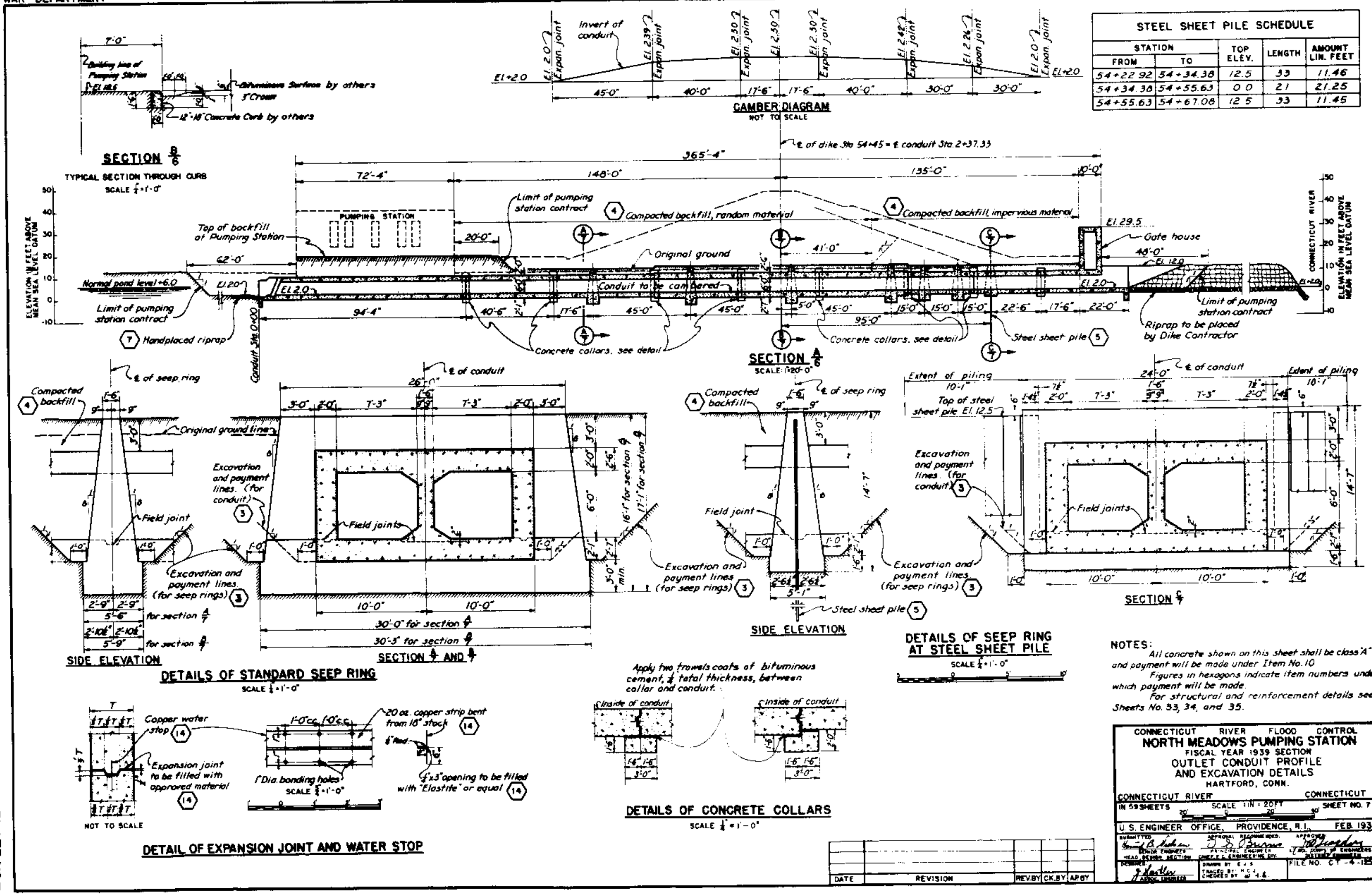


PLATE NO.6

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY



STEEL SHEET PILE SCHEDULE				
STATION		TOP ELEV.	LENGTH	AMOUNT LIN. FEET
FROM	TO			
54+22.92	54+34.38	12.5	33	11.46
54+34.38	54+55.63	0.0	21	21.25
54+55.63	54+67.08	12.5	33	11.45

NOTES:

All concrete shown on this sheet shall be class "A" and payment will be made under Item No. 10

Figures in hexagons indicate item numbers under which payment will be made.

For structural and reinforcement details see Sheets No. 33, 34, and 35.

DATE	REVISION	REV.BY	CK.BY	AP.BY

CONNECTICUT RIVER FLOOD CONTROL
NORTH MEADOWS PUMPING STATION
FISCAL YEAR 1939 SECTION
OUTLET CONDUIT PROFILE
AND EXCAVATION DETAILS
HARTFORD, CONN.

CONNECTICUT RIVER — CONNECTICUT

IN 59 SHEETS — SCALE 1 IN = 20 FT — SHEET NO. 7

U. S. ENGINEER OFFICE, PROVIDENCE, R.I. FEB. 1939

SUBMITTED: SENIOR ENGINEER, HEAD, DESIGN SECTION — APPROVAL RECOMMENDED: PRINCIPAL ENGINEER, CHIEF F.C. ENGINEERING DIV. — APPROVED: LT. COL. CORPS OF ENGINEERS, DISTRICT ENGINEER

DESIGNED: ASSOC. ENGINEER — DRAWN BY: E.J.S. — TRACED BY: H.C.J. — CHECKED BY: W.A.E. — FILE NO. CT-4-1255

PLATE NO. 7

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY

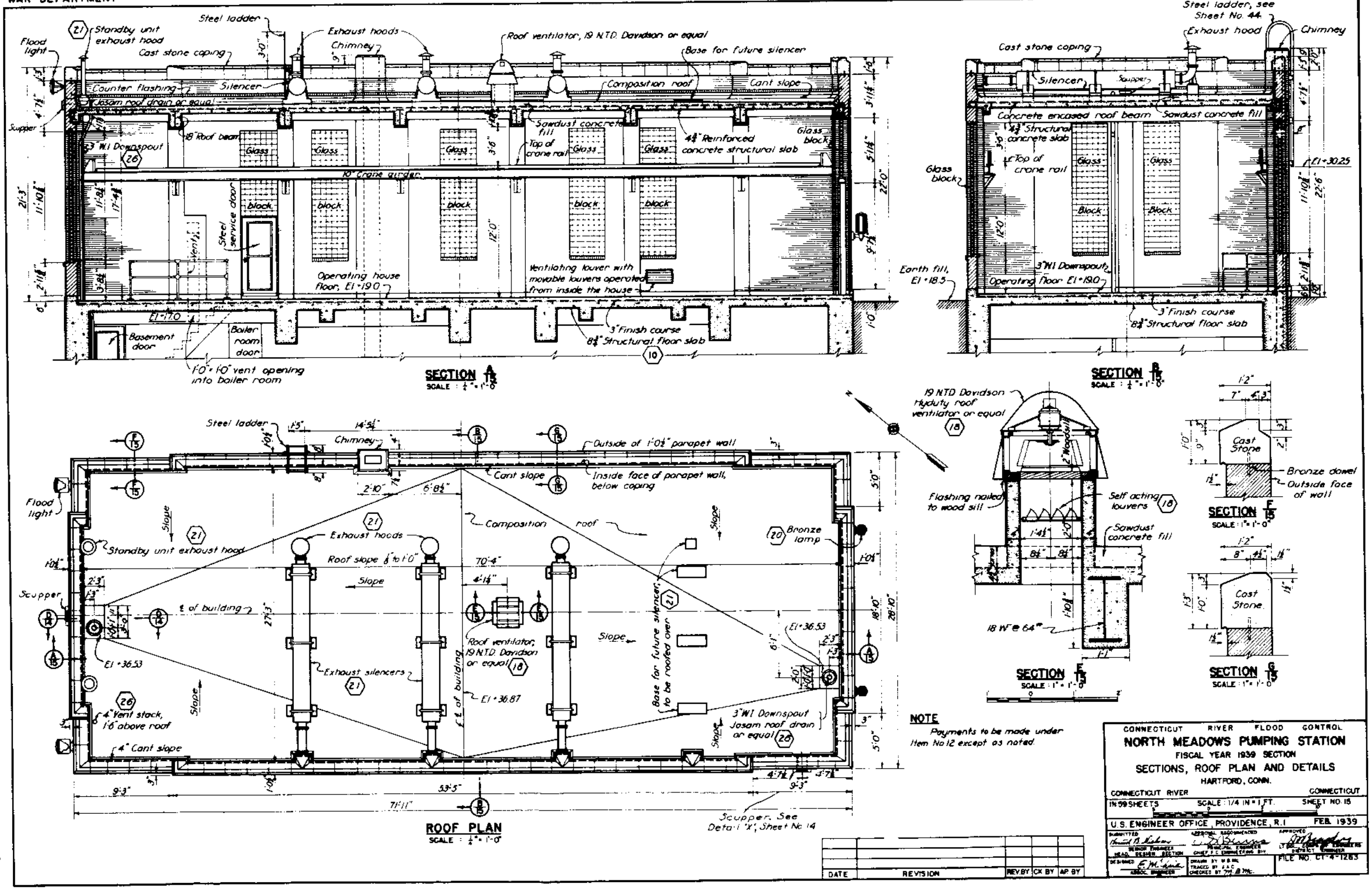


PLATE NO. 8

WAR DEPARTMENT

CORPS OF ENGINEERS, U. S. ARMY

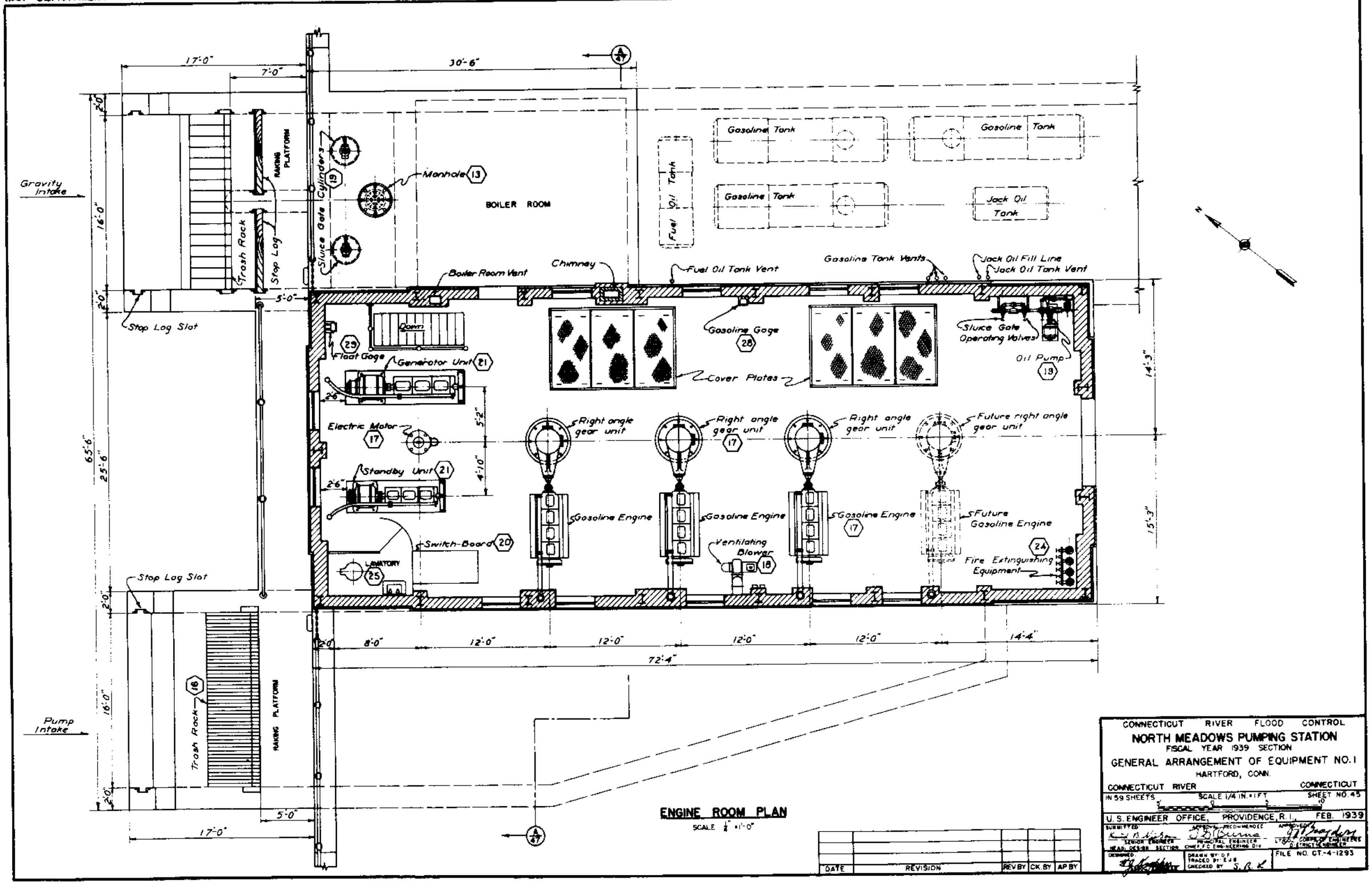
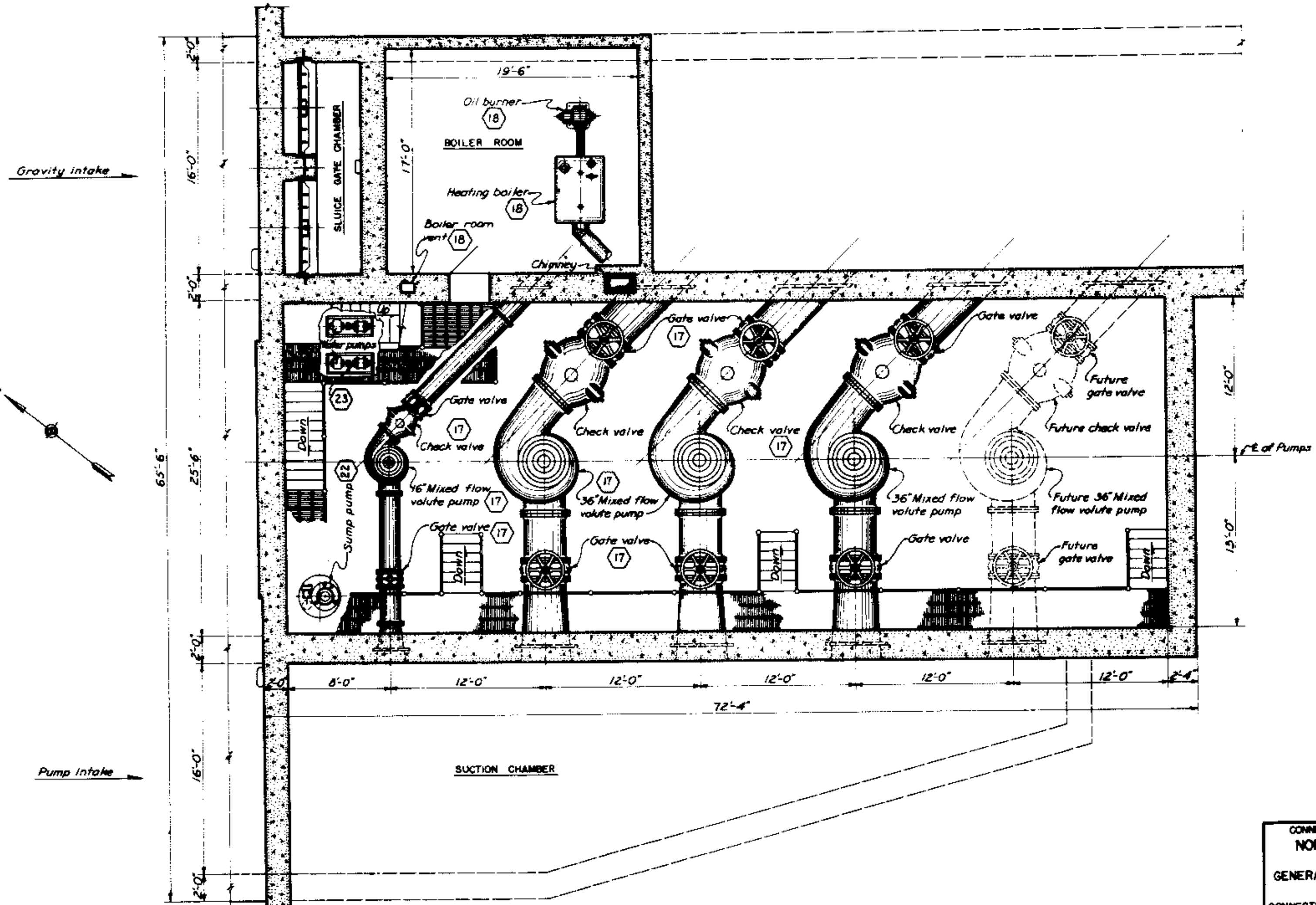


PLATE NO. 9

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY



PUMP ROOM PLAN

SCALE 1/4" = 1'-0"

DATE	REVISION	REV.BY	CK.BY	AP.BY

CONNECTICUT RIVER FLOOD CONTROL

NORTH MEADOWS PUMPING STATION

FISCAL YEAR 1939 SECTION

GENERAL ARRANGEMENT OF EQUIPMENT NO.2

HARTFORD, CONN.

CONNECTICUT RIVER — CONNECTICUT

IN 59 SHEETS — SCALE 1/4 IN. = 1 FT. — SHEET NO. 46

U.S. ENGINEER OFFICE, PROVIDENCE, R.I. — FEB. 1939

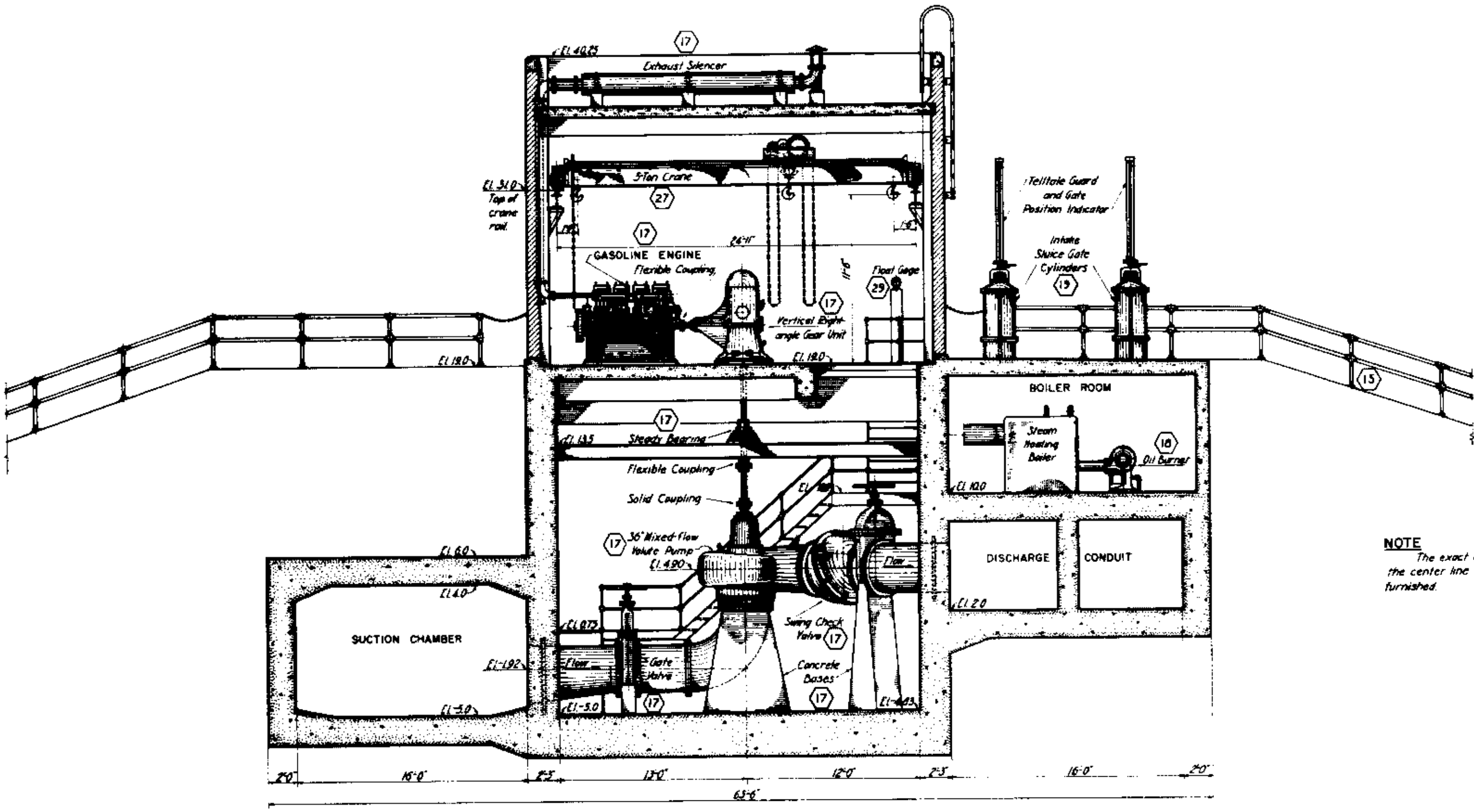
SUBMITTED: SENIOR ENGINEER, HEAD, DESIGN SECTION — RECOMMENDED: PRINCIPAL ENGINEER, CHIEF, F.C. ENGINEERING DIV. — APPROVED: LT. COL., CORPS OF ENGINEERS, DISTRICT ENGINEER

DESIGNED: ASSOC. ENGINEER — DRAWN BY O.F. — TRACED BY H.G.J. — CHECKED BY S.A.L. — FILE NO. CT-4-1294

PLATE NO. 10

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY



SECTION A/45

SCALE 1/4" = 1'-0"

NOTE

The exact elevation of the steady bearing and the center line of the pump shall suit the equipment furnished.

DATE	REVISION	REV.BY	CK.BY	AP.BY

CONNECTICUT RIVER FLOOD CONTROL
NORTH MEADOWS PUMPING STATION
FISCAL YEAR 1939 SECTION
GENERAL ARRANGEMENT OF EQUIPMENT NO. 3
HARTFORD, CONN.

CONNECTICUT RIVER — CONNECTICUT
IN 59 SHEETS — SCALE: 1/4 IN. = 1 FT. — SHEET NO. 47

U.S. ENGINEER OFFICE, PROVIDENCE, R.I. — FEB. 1939

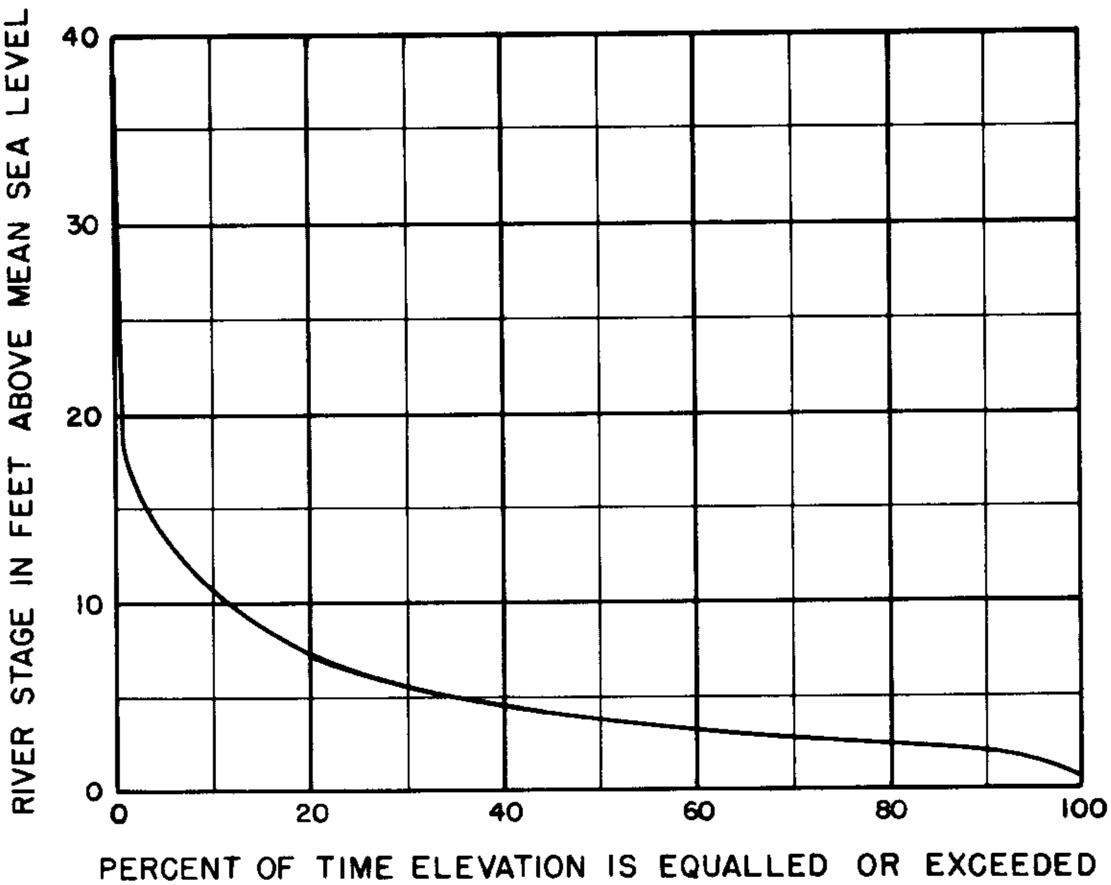
SUBMITTED: SENIOR ENGINEER, HEAD, DESIGN SECTION
APPROVAL RECOMMENDED: PRINCIPAL ENGINEER, CHIEF, F.C. ENGINEERING DIV.
APPROVED: LT. COL., CORPS OF ENGINEERS, DISTRICT ENGINEER
DESIGNED
DRAWN BY D.F.
TRACED BY H.R.R.
CHECKED BY S.R.

FILE NO. CT-4-1295

PLATE NO. 11

HARTFORD NORTH MEADOWS PUMPING STATION

STAGE-DURATION CURVE OF CONNECTICUT RIVER
AT
PUMPING STATION OUTLET



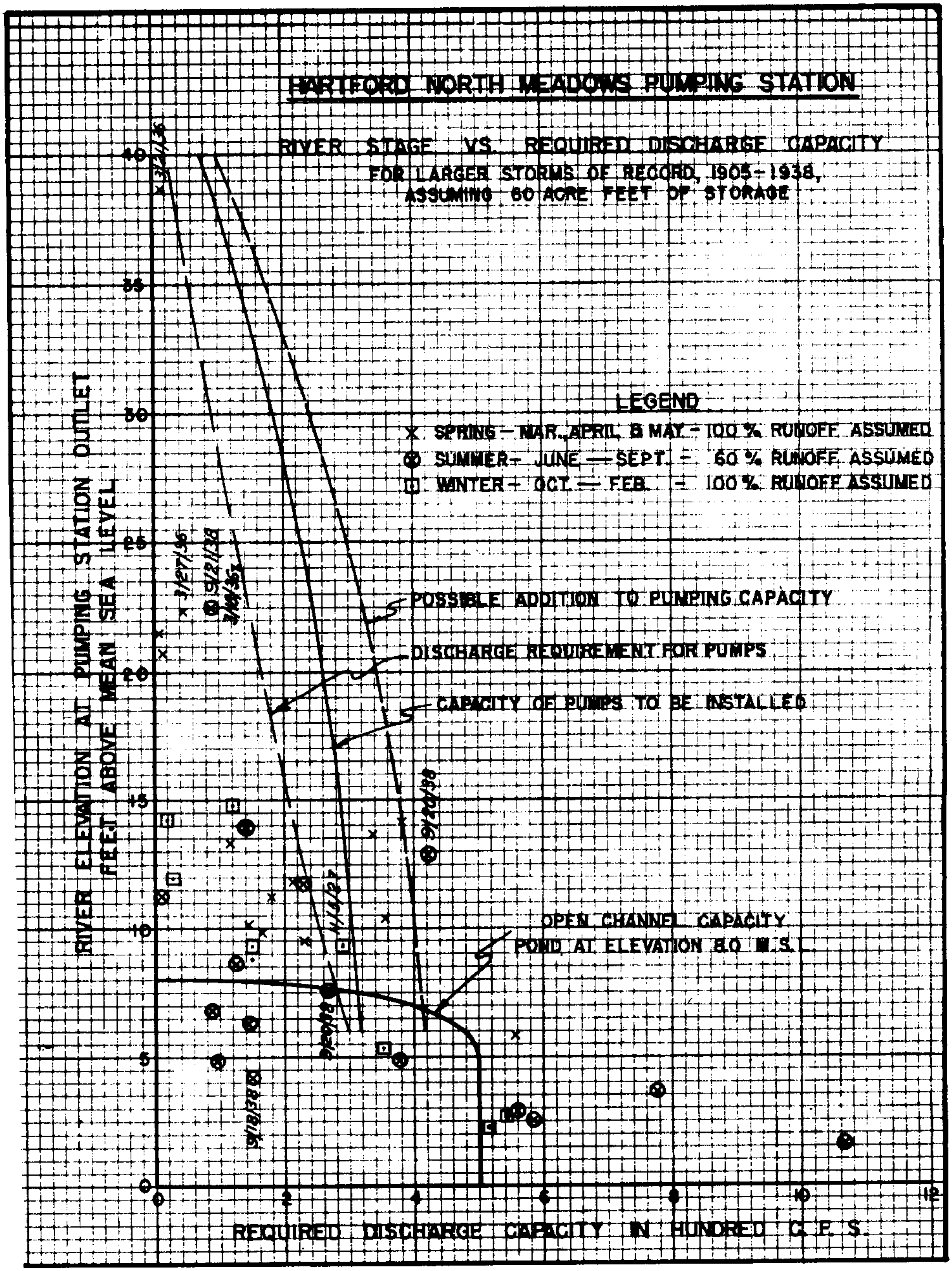

HARTFORD NORTH MEADOWS PUMPING STATION
RIVER STAGE VS. REQUIRED DISCHARGE CAPACITY
FOR LARGER STORMS OF RECORD, 1905-1938,
ASSUMING 60 ACRE FEET OF STORAGE
LEGEND
X SPRING - MAR., APRIL & MAY - 100 % RUNOFF ASSUMED
SUMMER - JUNE — SEPT. - 60 % RUNOFF ASSUMED
WINTER - OCT. — FEB. - 100 % RUNOFF ASSUMED
POSSIBLE ADDITION TO PUMPING CAPACITY
DISCHARGE REQUIREMENT FOR PUMPS
CAPACITY OF PUMPS TO BE INSTALLED
OPEN CHANNEL CAPACITY
POND AT ELEVATION 8.0 M.S.L.
RIVER ELEVATION AT PUMPING STATION OUTLET
FEET ABOVE MEAN SEA LEVEL
REQUIRED DISCHARGE CAPACITY IN HUNDRED C. F. S.
3/21/36
3/27/36
9/21/38
3/14/36
11/4/27
9/20/38
9/18/38

PLATE NO. 13

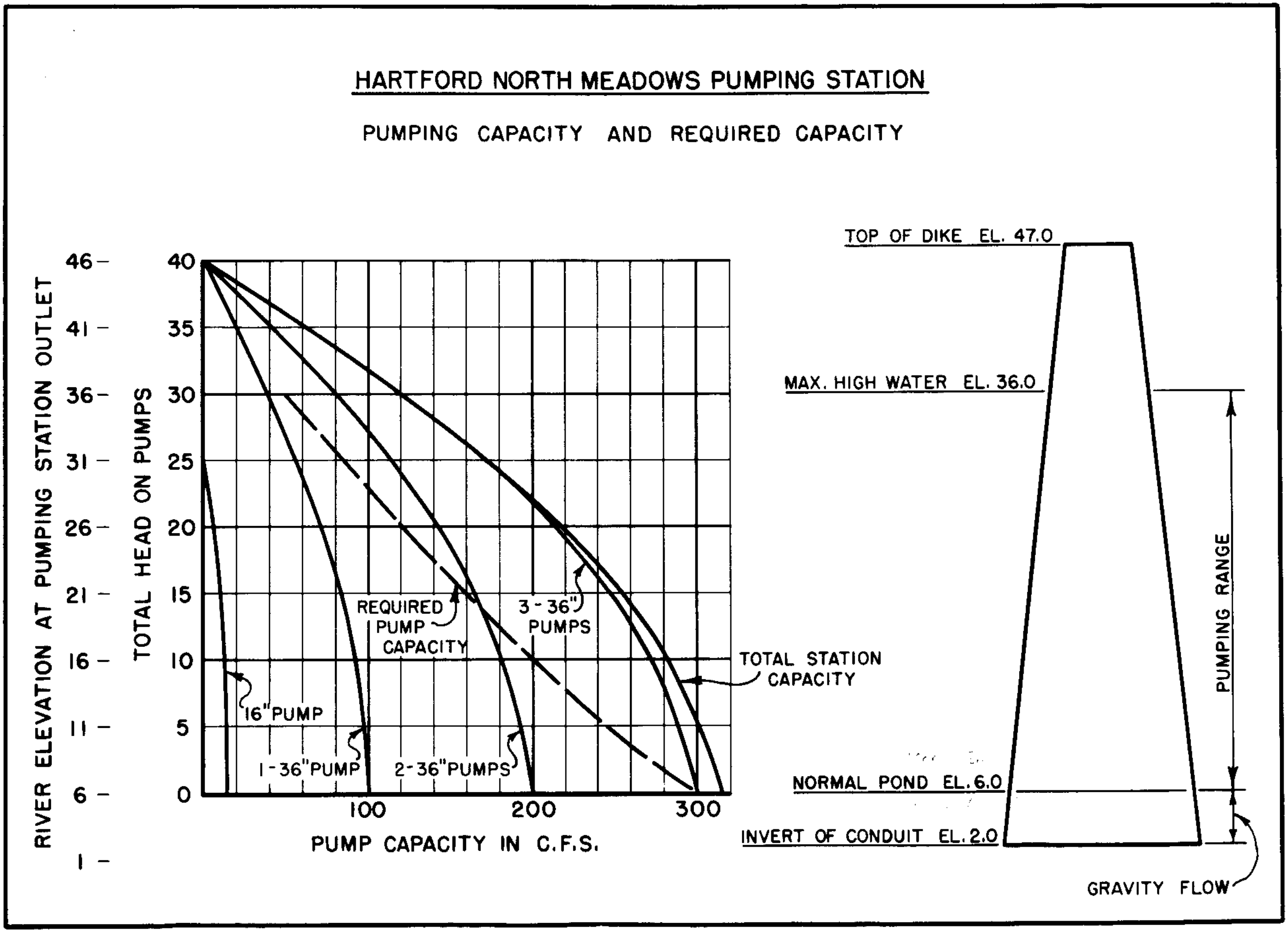
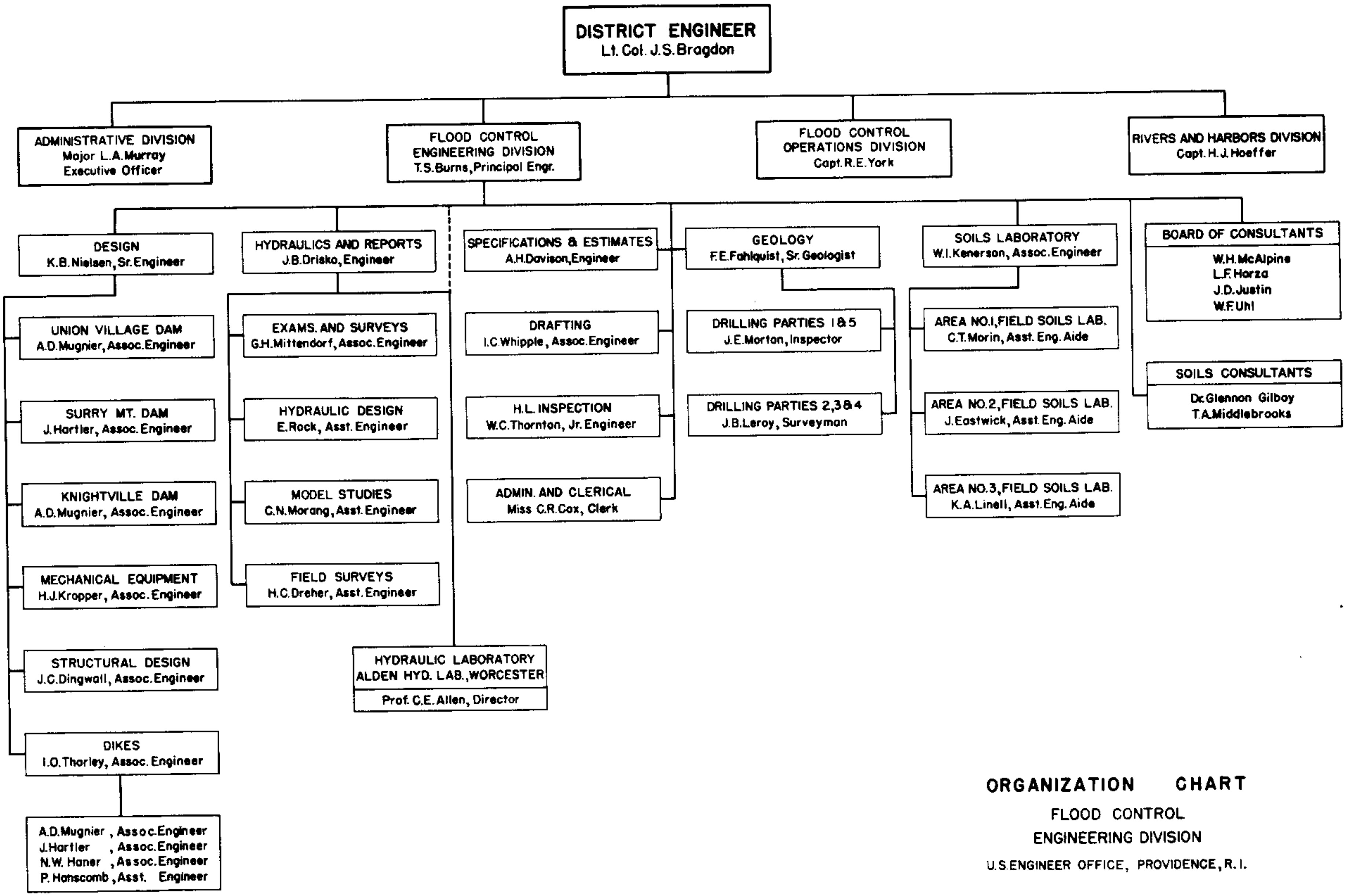

HARTFORD NORTH MEADOWS PUMPING STATION
PUMPING CAPACITY AND REQUIRED CAPACITY
RIVER ELEVATION AT PUMPING STATION OUTLET
TOTAL HEAD ON PUMPS
PUMP CAPACITY IN C.F.S.
16" PUMP
1-36" PUMP
2-36" PUMPS
3-36" PUMPS
REQUIRED PUMP CAPACITY
TOTAL STATION CAPACITY
TOP OF DIKE EL. 47.0
MAX. HIGH WATER EL. 36.0
PUMPING RANGE
NORMAL POND EL. 6.0
INVERT OF CONDUIT EL. 2.0
GRAVITY FLOW

PLATE NO. 14



ORGANIZATION CHART

FLOOD CONTROL
ENGINEERING DIVISION

U.S. ENGINEER OFFICE, PROVIDENCE, R.I.

PLATE NO. 15